EIGHTEENTH ANNUAL

REPORTS

OF

Rutgers Scientific School,

THE STATE COLLEGE

FOR THE BENEFIT OF

AGRICULTURE AND THE MECHANIC ARTS,

NEW BRUNSWICK, N. J.,

FOR THE YEAR 1882.

JERSEY CITY, N. J.:
PRINTED BY M. MULLONE.
1882.

EIGHTEENTH ANNUAL

REPORTS

OF

Rutgers Scientific School,

THE STATE COLLEGE

FOR THE BENEFIT OF

AGRICULTURE AND THE MECHANIC ARTS,

NEW BRUNSWICK, N. J.,

FOR THE YEAR 1882.

JERSEY CITY, N. J.:
PRINTED BY M. MULLONE.
1882.

BOARD OF VISITORS.

FIRST CONGRESSIONAL DISTRICT.

	Residences.	*Terms Expire.*
Hon. THOMAS H. DUDLEY,	Camden,	April 12, 1884.
I. M. SMALLEY, Esq.,	Roadstown,	April 12, 1883.

SECOND CONGRESSIONAL DISTRICT.

Hon. WILLIAM PARRY,	Cinnaminson,	April 12, 1883.
WILLIAM S. TAYLOR, Esq,	Burlington,	April 12, 1884.

THIRD CONGRESSIONAL DISTRICT.

Hon. JOHN W. HERBERT,	Wickatunk,	April 12, 1884.
JAMES NEILSON, Esq.,	New Brunswick,	April 12, 1884.

FOURTH CONGRESSIONAL DISTRICT.

JOHN DEMOTT, Esq,	Middlebush,	April 12, 1883.
CALEB WYCKOFF, Esq.,	Belvidere,	April 12, 1884.

FIFTH CONGRESSIONAL DISTRICT.

Rev. JOHN H. ROBINSON,	Paterson,	April 12, 1884.
CORNELIUS A. WORTENDYKE, Esq.,	Wortendyke,	April 12, 1883.

SIXTH CONGRESSIONAL DISTRICT.

PATRICK T. QUINN, Esq.,	Newark,	April 12, 1884.
WILLIAM M. FORCE, Esq.,	Newark,	April 12, 1883.

SEVENTH CONGRESSIONAL DISTRICT.

ABRAHAM W. DURYEE, Esq.,	New Durham,	April 12, 1884.
JAMES STEVENS, Esq.,	Jersey City,	April 12, 1884.

OFFICERS.

Hon. WILLIAM PARRY, *Chairman.*

GEORGE H. COOK, *Secretary.*

REPORT OF STATE BOARD OF VISITORS.

To His Excellency George C. Ludlow, Governor of the State of New Jersey:

HONORED SIR—The Board of Visitors of the State Agricultural College herewith present their eighteenth annual report of the present condition and course of instruction, as required in the act creating the Board, entitled "An Act appropriating scrip for lands granted to the State of New Jersey by the Act of Congress, approved July 2, 1862," and approved April 4, 1864.

The Board have held two regular meetings since the last report was made, have attended the examination of the students, have visited the laboratories and collections of the College, and the farm belonging to the Agricultural College, to witness the business and experiments in progress there. Upon each of these points they would respectfully report.

The first meeting of the Board was held on the 16th of December, 1881, and the members attended the following examinations:

Seniors, in Mechanics, by Prof. Bowser.
Juniors, in Political Economy, by Prof. Atherton.
Sophomores, in Descriptive Geometry, by Prof. Hasbrouck.
Sophomores, in Surveying, by Prof. Bowser.
Freshmen, in Geometry, by Lieut. Holmes.
Freshmen, in English Literature, by Prof. Hart.
Second Year Chemicals, in Analytical Chemistry, by Prof. Austen.
First Year Chemicals, in Analytical Chemistry, by Prof. Austen.
Linear Drawings of all the classes, by Prof. Hasbrouck.
Laboratory Exercises, by all the Chemical Electives and Specials.

The members of the Board individually expressed their views upon the examinations attended, the progress of the students, and the character of the studies pursued, also their satisfaction with the preparations made by the College to carry out the purposes of the State institution, and directed the Secretary to prepare and enter upon the minutes a resolution embodying their expressed views, which was done as follows:

Resolved, That we, the Board of Visitors to the State Agricultural College, appointed to see to the interests of the State in this institution, having attended the examinations of the students and visited the buildings, collections and lecture rooms provided for their instruction, and impressed with the importance and influence of the scientific and practical instruction here given to young men preparing for industrial and busi-

ness life, place upon record our high appreciation of the course of instruction provided by the Trustees of Rutgers College, and our satisfaction with the faithful and liberal manner in which they are fulfilling their responsibilities to the State.

The Secretary reported the following as the list of students on County Scholarships, and the counties from which their appointments are received:

Atlantic,	.....
Bergen,	J. W. McKelvey (resident of Middlesex).
Burlington,	Benjamin Lippincott.
Camden,	Wm. H. Luster (resident of Union).
Cape May,	Frederick W. Bennett.
Cumberland,	George H. Blakeley (resident of Somerset).
Essex,	M. George Bierman. John E. Hill. E. T. Ward. F. T. Ward.
Gloucester,	George B. Hurff.
Hudson,	Jackson Jaques (resident of Middlesex). Cyrus W. F. Sproul (resident of Monmouth). Philip Lindsley (resident of Somerset). Montfort Matthews (resident of Somerset).
Hunterdon,	N. B. K. Hoffman.
Mercer,	Francis Stryker.
Middlesex,	Arthur C. Payne. George W. Hart.
Monmouth,	Louis F. Ruf. Frank Van Brakle.
Morris,	George E. Jenkins.
Ocean,	George H. Johnson (resident of Middlesex).
Passaic,	Asher Atkinson (resident of Middlesex).
Salem,	.....
Somerset,	William L. Haynes.
Sussex,	.....
Union,	Frank S. Smith (resident of Middlesex). Henry R. L. Worrall.
Warren,	.....

It was reported that the Congressional bill for the creation of an Educational Fund was again before Congress, and the Secretary was directed to prepare a memorial to our members of Congress, expressing their approval of the bill and of its importance to the cause of education, and ask them to do all they can to urge its passage.

The Board held a second meeting at the College for the semi-annual examination of the students, June 15th, 1882, when they attended the following examinations:

Juniors, in Calculus, by Prof. Browser.
Juniors, in Chemistry, by Prof. Austen.
Juniors, in History, by Prof. Atherton.
Juniors, in German, by Prof. Meyer.

Sophomores, in Railroad Curves, by Prof. Bowser.
Sophomores, in Chemistry, by Prof. Van Dyck.
Sophomores, in Mental Philosophy, Prof. Doolittle.
Sophomores, in Descriptive Geometry, Prof. Hasbrouck.
Sophomores, in Constitutional History of England, by Prof. Atherton.
Freshmen, in Botany, by Prof. Van Dyck.
Freshmen, in English Literature by Prof. Hart.
Freshmen, in French, by Prof. Meyer.
Freshmen, in Plane Trigonometry, by Lieut. Holmes.

There was an exhibition of the Draughting of the different classes under the direction of Prof. Hasbrouck; Laboratory Practice under the supervision of Prof. Austen, and a Military Drill under the command of Lieut. Holmes.

The visitors then listened to the reading of the following theses by members of the graduating class:

Frederick W. Bennett, Cape May Court House, N. J., "The Delaware Breakwater."
Philip H. Bevier, Gardiner, N. Y., "The Weehawken Tunnel."
N. B. K. Hoffman, Readington, N. J., "The East River Bridge."
George H. Johnson, New Brunswick, N. J., "The Niagara Suspension Bridge."
Solomon Le Fevre, New Paltz, N. Y., "The Mississippi Jetties."

The Board expressed their gratification at the manner in which the students had acquitted themselves, as well as at the faithful manner in which the teachers had drilled them. It was also reported that the Board of Managers of the Experiment Station, which is made up from this Board, had visited the College Farm on the 12th inst., and had gone over and inspected the growing crops and stock. They had found the farm in excellent condition, and the numerous experiments with fertilizers and crops very instructive and profitable. The Board then directed a resolution to be entered on their minutes, expressing their judgment that "The Trustees and Faculty of Rutgers College are fully and faithfully carrying out their contract with the State in regard to Rutgers Scientific School, and the institution is doing most valuable work for the State and for scientific and practical education."

A letter from one of the County Superintendents was read, in which he suggested public competitive examinations for those who were applicants for county scholarships.

The following is a list of the names of students holding State scholarships who are now pursuing their studies at the Scientific School, with the county scholarships they occupy and the counties in which they reside:

Atlantic,	Frank S. Smith, resident of Middlesex.
Bergen,	J. W. McKelvey, resident of Middlesex.
Burlington,	Joseph B. Reynolds, resident of Burlington. John H. Porter, resident of Burlington.
Camden,	George H. Blakeley, resident of Somerset.
Cape May,	.....

Cumberland,	John Elmer, resident of Cumberland.
Essex,	John E. Hill, resident of Essex. F. T. Ward, resident of Essex. C. W. Harrison, resident of Essex. S. D. Stryker, resident of Essex. F. S. Nelson, resident of Middlesex.
Gloucester,	.....
Hudson,	Jackson Jaques, resident of Middlesex, Peter M. Matthews, resident of Somerset. Philip Lindsley, resident of Somerset. R. J. Fulton, resident of Middlesex.
Hunterdon,	Ulysses G. Davis, resident of Hunterdon.
Mercer,	C. S. Cathcart, resident of Middlesex.
Middlesex,	Arthur Payne, resident of Middlesex. George W. Hart, resident of Middlesex.
Monmouth,	C. W. F. Sproul, resident of Monmouth. Frank Van Brakle, resident of Monmouth.
Morris,	George E. Jenkins, resident of Morris.
Ocean,	.....
Passaic,	Asher Atkinson, resident of Middlesex.
Salem,	Clarence Du Bois, resident of Cumberland.
Somerset,	Wm. L. Haynes, resident of Somerset.
Sussex,	Edson D. Eaton, resident of Sussex.
Union,	Wm. H. Luster, resident of Union. Henry R. L. Worrall, resident of Union.
Warren,	Frank W. Ribble, resident of Somerset.

In closing this report the Board desire to express their satisfaction with the way in which the Trustees are carrying out their contract with the State. The means for instruction, both in men and material, are good; the graduates of the institution are entering mainly upon work where their education in science is being applied so as to benefit themselves and the communities in which they are to live. The free intercourse of the scientific students with those of Rutgers College, and in some cases pursuing the same studies, is productive of benefit to both. The students are taught to write and speak as well as to acquire knowledge, and they are thus prepared to make their learning available not only for themselves, but also for the communities in which they live. It would be greatly for the benefit of our country if more of those who are to lead in the industrial and business pursuits of life could enjoy the benefits of the liberal and scientific education which is given in the New Jersey State Agricultural College.

We commend this institution and its interests to your favorable consideration, and to the fostering care of the State.

All of which is respectfully submitted.

WILLIAM PARRY,

President Board of Visitors of State Agricultural College.

TRUSTEES' REPORT.

RUTGERS COLLEGE,
NEW BRUNSWICK, December 1st, 1882.

To His Excellency George C. Ludlow, Governor of the State of New Jersey:

SIR—In compliance with the act of Congress, approved July 2d, 1862, and the act of the Legislature of New Jersey, approved April 4th, 1864, I beg leave to submit, on behalf of the Trustees of Rutgers College, the eighteenth annual report of Rutgers Scientific College.

I. THE FACULTY.

The faculty of the institution is now constituted as follows:

Merrill Edwards Gates, PH.D., LL.D., President, and Professor of Moral Philosophy.

Rev. William H. Campbell, D.D., LL.D., ex-President, and Professor of the Evidences of Christianity.

George H. Cook, PH.D., LL.D., Vice President, and Professor of Geology and Agriculture.

Rev. Theodore S. Doolittle, D.D., Professor of Rhetoric, Logic and Mental Philosophy.

John C. Smock, A.M., PH.D., Professor* of Mining and Metallurgy.

Rev. Carl Meyer, D.D., Professor of French and German.

Francis C. Van Dyck, A.M., Professor of Physics and Experimental Mechanics,

Edward A. Bowser, C.E., LL.D., Professor of Mathematics and Engineering.

Isaac E. Hasbrouck, A.M., Professor of Mathematics and Graphics.

George B. Merriman, A.M., Professor of Mathematics and Astronomy.

Peter Townsend Austen, PH.D., F.C.S., Professor of General and Applied Chemistry.

* The duties of this professorship are not at present discharged; the chair awaits endowment.

Francis A. Wilber, M.S., Assistant in Analytical Chemistry.

Frank Loring Dodds, Second Lieutenant Ninth United States Infantry, Professor of Military Science and Tactics.

Austin Scott, A.M., Ph.D., Professor of History, Political Economy and Constitutional Law.

II. COURSES OF STUDY AND DEGREES.

The courses of study in the Scientific School are as follows:

1. *A course of four years in Civil Engineering and Mechanics.*

2. *A course of four years in Chemistry and Agriculture.*

3. *A special course of two years in Chemistry.*

4. *A special course of two years in Agriculture.*

5. *Post-Graduate courses.*

The two principal courses cover a period of four years each. The studies for the first year are the same in both courses, and are arranged with special reference to the wants of young men who desire to fit themselves to become land surveyors, or to enter any department of skilled industry, but are unable to remain four years in the institution.

At the end of the first year students elect whether to pursue the course in Civil Engineering and Mechanics, or that in Chemistry and Agriculture, and for the remaining three years their studies are directed with particular reference to the choice made. Some studies, however, of a general nature, such as History, English Literature, Political Economy, Moral Philosophy and others, are interspersed throughout the entire four years, in order that students may not only acquire a thorough preparation for their special pursuits in life, but may at the same time receive a liberal training which will fit them to discharge wisely and usefully the duties of good citizenship.

Students completing either of the four years' courses receive the degree of Bachelor of Science.

Heretofore, the degree of Master of Science has been conferred, in course, upon all graduates of three years' standing. The Trustees have long been convinced that the practice of conferring high academical honors, indiscriminately, without regard to the character or attainments of those who receive them, is an unfair discrimination against those who have honorably earned recognition, and calculated to bring all such marks of distinction into undeserved discredit.

They have accordingly decided to confer, hereafter, no degrees "in course," but only on examination or for work done, and they regard this as an important step in the direction of maintaining a high standard of scholarship.

The degrees of Civil Engineer and Doctor of Philosophy are conferred for distinguished professional or practical success, or on examination in prescribed subjects.

The conditions on which the degrees are given will be found fully explained in the Catalogue of Rutgers College.

The SPECIAL COURSE IN CHEMISTRY is intended for the convenience of students who wish to devote themselves exclusively to that branch of study. Greatly increased facilities have recently been provided for them in the laboratory and lecture rooms, allowing the full employment of their time. On completing the course they receive a special certificate.

The SPECIAL COURSE IN AGRICULTURE affords young men an opportunity of acquiring, in the shortest time, the scientific knowledge necessary to success in practical farming. Students who pass their regular examination in the required subjects, will, at the close of their course, receive certificates of their attainments. And at the end of two or more years further, if they shall have pursued practical agriculture on a farm, and shall then pass satisfactory examinations in prescribed subjects on Agricultural Principles and Practice, before a Board of Examiners of the Scientific School, they shall receive Diplomas in Agriculture.

Provision is also made for PARTIAL STUDENTS, who may enter at any time, and elect, under the advice and direction of the Faculty, such studies as they may be found qualified to pursue with classes already formed. Such students are subject to the general regulations and discipline of the institution. They are required to have their time fully occupied, and to pass such examinations as may be prescribed in each case. On leaving, they receive certificates stating the studies pursued and the amount of work performed in each.

A schedule of the several courses of study accompanies this report.

III. POST-GRADUATE STUDIES.

In addition to these courses of study for the under-graduates, several post-graduate courses have been arranged (and the number will be increased as occasion requires) for students who desire, after graduation, to pursue special lines of training and research.

In CHEMISTRY, students can pursue special studies and investigations in the Analytical Laboratory, under the direction of a professor, upon subjects connected with industrial or professional life.

In GEOLOGY and NATURAL HISTORY the large collections in Geological Hall are available for extended courses of study, and can

be used under the direction of a professor, for special study in Geology, Mining, Metallurgy, and the various branches of Engineering.

In AGRICULTURE, the well-equipped farm and laboratories give unusual opportunities for advanced studies in this department, and every facility is afforded for their use.

In MATHEMATICS, instruction will be given in any of the following subjects: Geodesy, with practice; Higher Mathematics (pure); Theoretical and Practical Astronomy; the use of Physical Apparatus.

In MODERN LANGUAGES, the course will include Lectures on French Literature, Lectures on German Literature, Lectures on German Etymology, on German Mythology, and on the Phonology and Morphology of the Indo-Germanic Languages, as bearing on German; and an advanced course in the History and Literature of the English Language.

In the DEPARTMENT OF POLITICAL AND SOCIAL SCIENCE, provision is made for instruction in an advanced course in Political Economy; in the Constitutional History and Jurisprudence of the United States; in the History of the English Constitution; and in the elements of Roman Law.

These various subjects, according to the choice of students, will be arranged in courses of one, two or three years.

Students completing a full course of two years, in any two of the departments, will be entitled to the degree of Doctor of Science.

IV. TERMS OF ADMISSION.

Every applicant for admission must be sixteen years of age, and must submit to the President proper testimonials of a good moral character. If an applicant for a State Scholarship, he must also present to the President a certificate of appointment from the County Superintendent.

Examinations for admission will be held on the same days as for the Classical Department, viz., on the Monday and Tuesday preceding Commencement, June 18th and 19th, beginning at 10 o'clock A. M. on Monday, in the President's room. Applicants for admission may also be examined on Thursday, September 20th, at the same hour and place; but all students who can conveniently do so, are advised to be present in June.

Students may enter an advanced class either at the beginning of the College year or at other times, on condition that they sustain a satisfactory examination both on the preliminary studies and on those already passed over by the class which they propose to enter.

Provision is made for such students as wish to devote themselves to special subjects, if they are prepared to study profitably with the regular classes in those subjects.

The following are the subjects in which those desiring to enter the Freshman Class of the Scientific Department are examined. As they are all such as can be acquired in our best common schools, it is insisted that the preparation in them shall be thorough and complete.

1. ARITHMETIC.—Fundamental Operations; Common and Decimal Fractions; Denominate Numbers, including the Metric System; Percentage, including Interest and Discount; Proportion; Extraction of the Square and Cube Roots.

2. ALGEBRA to Series; as much as is contained in Loomis' Treatise on Algebra, Wentworth's Complete Algebra, or Wells' University Algebra.

3. PLANE GEOMETRY. The *whole* of Plane Geometry will be required.

4. ENGLISH GRAMMAR—including spelling.

5. DESCRIPTIVE GEOGRAPHY.

6. PHYSICAL GEOGRAPHY.

7. HISTORY OF THE UNITED STATES.—Candidates for admission are examined in the History of the United States, with special reference to the colonization of the several States, the forms of government which existed previous to the Revolution, the causes and principal events of the Revolution, the period of the Confederation, the establishment of the Federal constitution, with the general history subsequent to that event.

[After 1883, such a knowledge of Elementary Physics and Chemistry as may be obtained from Peck's Ganot's Physics, or Wells' Natural Philosophy, and Valentine's Twenty Lessons in Chemistry, or Cooley's or Steele's Chemistry, will be required for admission.]

In preparing the student for this course, it is recommended that he be drilled thoroughly in Arithmetic, as a clear understanding of its simple elementary and practical principles is essential to a good Mathematician. His preparation in Algebra to Series should also be as complete. In addition to understanding the PRINCIPLES of the science he must fix them in his memory, and learn their bearing and utility, and for this reason he must pay great attention to the solution of practical examples. What is needed is ability to solve ordinary examples with facility and explain them thoroughly.

Attention is specially called to the Metric System of Weights and Measures, a practical knowledge of which is indispensable, since it is *used* in the class-room.

V. STUDENTS.

Of the four classes now in the institution, which will be graduated in June, 1883, 1884, 1885 and 1886, respectively, the Senior Class consists of two students, the Junior Class of nine, the Sophomore Class of thirteen, and the Freshman Class of nineteen. There are also five special students, making a total of forty-eight now in attendance.

There have been in the institution during the year, sixty-eight students, of whom one was from Cuba, one from the State of Pennsylvania, fourteen from the State of New York, and the remaining fifty-two from the State of New Jersey.

Under the law of New Jersey, designating this institution as "The State College for the Benefit of Agriculture and the Mechanic Arts," forty students from this State are entitled to free tuition for the entire course. These students are admitted on the recommendation of the Superintendent of Schools in each county, and are distributed among the counties in proportion to their representation in the Legislature.

In filling these State scholarships the Trustees have, from the first, adopted the most liberal interpretation of the law; and, in fact, have gone far beyond its requirements.

In cases where the scholarship is not filled by the county entitled to it, the Trustees have adopted the policy of allowing it to be filled temporarily, with the consent of the County Superintendent, by an applicant from some other county; and, in general, tuition is habitually remitted to students who are unable to pay that in addition to the other expenses of procuring an education.

Information regarding vacant scholarships, and the steps necessary to obtain them, etc., can be had by addressing the County Superintendents.

The following table shows the distribution of the scholarships among the counties, how each is filled, the number of vacancies, and the names and addresses of the County Superintendents.

COUNTIES.	Number of free Scholarships.	Filled by Students from Counties as follows.	Scholarships not Filled.	Names and Addresses of County Superintendents.
Atlantic	1	Middlesex	.....	S. R. Morse, Atlantic City.
Bergen	1	Middlesex	.....	John A. Demarest, River Edge.
Burlington	3	Burlington, 2.	1	Edgar Haas, Bordentown.
Camden	2	Somerset, 1...	1	F. R. Brace, Blackwood.
Cape May	1	.....	1	E. P. Shields, Dennisville.
Cumberland	1	Cumberland...	.....	William O. Garrison, Bridgeton.
Essex	6	Essex, 4..... Middlesex, 1..	1	Charles M. Davis, Bloomfield.
Gloucester	1	.....	1	William Milligan, Woodbury.
Hudson	6	Middlesex, 2.. Somerset, 2...	2	William L. Dickinson, Jersey City.
Hunterdon	1	Hunterdon ...	.....	R. S. Swackhamer, White House.
Mercer	2	Middlesex, 1..	1	W. J. Gibbey, Princeton.
Middlesex	2	Middlesex	.....	Ralph Willis, New Brunswick.
Monmouth	2	Monmouth ...	.....	Samuel Lockwood, Freehold.
Morris	2	Morris, 1.....	1	Lewis W. Thurber, Dover.
Ocean	1	.....	1	Edward M. Lonan, Forked River.
Passaic	2	Middlesex, 1..	1	J. C. Cruikshank, Little Falls.
Salem	1	Cumberland ..	.....	R. Henry Holme, Salem.
Somerset	1	Somerset	.....	John S. Haynes, Raritan.
Sussex	1	Sussex	.....	Luther Hill, Andover.
Union	2	Union.....	.....	N. W. Pease, Elizabeth.
Warren	1	Somerset	.....	Robert S. Price, Hackettstown.

II.—Table Showing the Occupation of 99 *of the Students of Rutgers Scientific School who have Graduated, and of* 60 *who have left without Graduating, from the beginning to September,* 1881, *inclusive, these being the only ones whose occupation is certainly known.*

STUDENTS.	OCCUPATIONS.							
	Engineer.	Architect.	Manufact'rer.	Farmer.	Physician.	Lawyer.	Teacher.	Business.
Who graduated	41	3	14	6	8	8	9	10
Per cent	41	3	14	6	8	8	9	10
Who did not graduate	6	2	6	13	4	3	4	22
Per cent	10	3	10	22	6	6	6	37
Totals	47	5	20	19	12	11	13	32
Per cent	29	3	13	12	8	7	8	20

The names and addresses of the students will be found in the Catalogue of Rutgers College. Positions held and work done by some of those who have recently studied here is recorded below:

Geo. W. Kuehnle, '76, is in charge of River and Harbor Improvements on Raritan river.

L. F. Loree, '77, is a Civil Engineer on the Penn. R. R.

C. T. Pomeroy, '77, is a successful manufacturer of inks in Newark, N. J.

Geo. M. Taylor, '77, is a Civil Engineer on the Penn. and New England R. R.

J. Tice, '77, is a Civil Engineer on the Penn. R. R.

A. A. Titsworth, '77, is Assistant Civil Engineer on the Geodetic Survey of New Jersey.

*E. M. Culver, '78, (M. D.,) fills an important position in Bellevue Hospital, New York City.

E. Duryee, '78, is a Metallurgist in Colorado.

W. L. Lawrence, '78, is a Civil and Mining Engineer, Agent of the Burden Iron Co.

R. W. Prentiss, '78, was a Fellow in Mathematics at Johns Hopkins University for two years, and is now in the Nautical Almanac Office, at Washington, D. C.

C. C. Vermeule, '78, is Assistant in charge of the Topographical Survey of New Jersey.

*S. I. Kudo, '78, is a Professor of Chemistry in the Agricultural College in Japan.

*R. A. Cook, '79, has filled the position of Chemist to the Oxford Iron Co., and Chemist to the Chesapeake Sugar Refinery, at Baltimore, Md.

C. W. Cutler, '79, (M. D.,) took the $500 prize at the New York College of Physicians and Surgeons in 1882.

Geo. Hill, '79, is a Civil Engineer on the Long Branch Improvement Works.

Geo. B. McChesney, '79, was First Assistant for two years in the N. J. Agricultural Experiment Station and is now Practical Chemist and Assistant Supt. of the Glen Cove Starch M'f'g Co., L. I.

J. B. Miller, '79, is the Inventor of the "Chordel."

A. B. Nelson, '79, is a Civil Engineer on the Penn. R. R.

F. A. Wilber, '79, is Assistant in Analytical Chemistry in Rutgers College.

C. M. Freeman, '80, held the position of Chemist to the Oxford Iron Co.

*J. A. Van Mater, '80, was for some time Chemist to the Rockhill Iron and Coal Co., Philadelphia, and is now a successful farmer,

J. H. Aitkin, '81, holds a responsible position in the Pottery Factory of Burroughs & Mountford, in Trenton, N. J.

T. H. Grant, '81, is a Civil Engineer on the Penn. and New England R. R.

F. W. Malcolm, '81, is a Civil Engineer on the Pittsburg, Cincinnati and St. Louis R. R.

J. T. Marshall, '81, is a Division Supt. in Edison's Electric Lamp Factory.

R. C. Plume, '81, is a Civil Engineer in charge of the Dredging Works in Boston Harbor

*E. B Voorhees, '81, for one year was Assistant to the Professor of Chemistry at Wesleyan University, Middletown, Conn., and is now First Assistant at the N. J. Agricultural Experiment Station.

Geo. B. Hurff, '82, holds the position of Second Assistant in the N. J. Agricultural Experiment Station.

F W. Bennett, '82, P. H. Bevier, '82, S. Le Fevre, '82, Assistants on the New Jersey State Topographical Survey.

N. B. K. Hoffman, '82, is a Civil Engineer in Virginia.

George H. Johnson, '82, is a Teacher in the Military Institute at Aurora, N. Y.

VI. SPECIAL DEPARTMENTS.

The method and scope of work in the several departments of the institution have undergone no particular change since the date of the

* Graduates of the Classical College who have pursued studies in the Scientific School.

last report, though it is but just to the gentlemen in charge to say that there are in each department gratifying indications of steady and vigorous growth.

1. MATHEMATICS.

In this course during the first year students are instructed in Algebra, Geometry, Trigonometry and Surveying, and receive sufficient field practice to make them able to survey farms, either with the compass or the transit, and to determine the magnetic variations. Those who take the Engineering course for the full term of four years are instructed in Descriptive Geometry, Railroad Curves, Analytic Geometry, Calculus, Mechanics, Civil Engineering, Bridge-building, Geodesy, etc., having at the same time daily practice in Draughting. Special attention is given to Mathematics rather than to Engineering, for the reason that a thorough training in the former necessarily precedes and is essential to a good knowledge of the latter, and in a four years' course a student cannot get both. It is pretty generally admitted by engineers, both civil and mining, that students should first take a thorough course in Mathematics, and obtain a knowledge of the theory of engineering, and then enter the field, or the office, as engineers' assistants and continue their course. In Geodesy, the students receive instruction in making a reconnoissance survey for a protracted triangulation system; the measurement of the base line, with its several reductions; erection of signals, measurement of horizontal angles and their adjustment by the "Method of Least Squares;" computation of latitude, longitude and azimuths, etc. For the past seven years some of the students of this department have been employed on the Geodetic Survey of New Jersey, and on the State topographical survey, with good results. The aim of the instruction is to ground the students firmly in Mathematics and to give them a knowledge of the theory of Engineering, so that after graduation they may be able to pursue understandingly and continuously an advanced course of mathematical study, or to go into the field or the office as engineers' assistants and do useful work.

2. GRAPHICS.

The instruction in this department is oral and by illustration or supervison, except in Descriptive Geometry. In this subject a textbook is used in the recitation room, while the principles there discussed are more fully illustrated by problems assigned for graphical solution in the draughting room.

During the entire course of four years the students are required to spend a certain number of hours each week in the draughting room in practical work in Drawing. In the Freshman year the practice begins with the use of the principal instruments employed in Mechanical Drawing. This practice is obtained in the solution of problems

in Plane Geometry, thus securing two ends, viz., a knowledge of the purposes of the instruments and of the manner of using them, and a knowledge of geometrical principles and their applications, particularly such modifications and applications of the principles as will give the shortest, neatest and most perspicuous methods of working. When the student has acquired some facility in the use of instruments, he is taught the methods of Topographical Drawing with practice in the use of colors, pen-signs, contour-lines, etc. Also the methods of Graphical Representation of Statistical Data. At the end of the first year's work, the student has had instruction sufficient to enable him to execute all the drawings required in Plane Surveying for farming purposes, etc.

In the Sophomore year, the course in Drawing is based on Descriptive Geometry, as that, at the beginning of the Freshman year, exercised the students' knowledge of Elementary Geometry. Besides the solution of problems in Solid Geometry, the course, during the year, includes practice in Shades and Shadows and Linear Perspective, the work being all directed by mathematical principles.

During the Junior and Senior years, the aim of the instruction is to acquaint the student with some of the many applications of the principles of Drawing additional to those in which he has had practice in the first two years. The limited time allowed to the subject, and the diversity of the intended pursuits of the students after graduation, prevent extended practice in any particular department of Drawing. The design, therefore, is to prepare intelligent and ready draughtsmen, familiar with fundamental principles and methods; men who will be valuable assistants in the draughting room of the architect or engineer, rather than accomplished masters in these professions; to give the student a safe beginning on which to grow more easily and surely into the practical designer.

3. ASTRONOMY.

The Daniel S. Schanck Observatory is a two-story brick building, with revolving dome, constructed especially for astronomical work. It contains in the main part the equatorial telescope, mounted on a pier of solid masonry extending several feet below the surface of the ground, and detached from the floors, through which it rises, so as to be unaffected by the tremors of the building. The telescope is eight feet four inches in focal length, with an aperture of six and one-half inches, and was made by the late Henry Fitz, of New York. It has a small telescope attached for a finder, a driving clock, a position micrometer, a number of eye pieces (two of superior quality having been recently added), a prism and glasses for solar observations. The declination circle is ten inches in diameter, reading by verniers to one minute of arc, and the hour circle, seven and one-half inches in diameter, reads by verniers to six seconds of time.

On the west side of the main part is an extension for transit obser-

vations. The meridian circle used for this work was made by Stackpole & Brother, of New York, and has an object-glass four inches in diameter and four feet ten inches in focal length, which circles seventeen inches in diameter, reading by two microscopes with micrometer screws to single seconds of arc. The diaphragm carries one horizontal and nine vertical wires. There is also a striding spirit-level and an apparatus for reversing the axis of the instrument. The bearings rest on two stone pillars supported by piers of masonry.

The Observatory has also a sidereal clock, by Wm. Bond & Son, the gift of John Clark, Esq., of New Brunswick, with an electrical break-circuit; a mean solar clock, the gift of the Piethessophian Society of Rutgers College, and a reflecting circle, the gift of the Philoclean Society of Rutgers College, and a chronograph loaned to the Observatory by the Superintendent of the United States Coast Survey.

The Observatory is in connection with the United States Naval Observatory and others, by the Western Union Telegraph Line, so that observations may be compared by exchange of time-signals. The instruments are all in good working condition, and the student of practical astronomy has here every facility for learning the methods of astronomical observation. Practice is acquired in observing transits both by the "eye and ear" method, and by chronographic signals, and also in making differential measurements with the micrometer.

A familiarity with the refined methods of measurement which astronomical instruments afford, and the habit of thinking for one's self which the use of such instruments helps to form, are in themselves no small means of mental culture. Add to this the familiar acquaintance with the elements of Spherical Astronomy and the useful methods of computation which the practical study of this most perfect of the sciences imparts, and the advantage and satisfaction to the student are readily manifest.

The elements of Astronomy are taught by the use of a text-book and by lectures four times a week during the last term of the Junior year. Those who elect a special course in Astronomy receive further instruction three times a week through the Senior year, learning the use of the instruments and taking part in the observations. Post-graduate students can take a still more extended course. Among the subjects included in the course are the following:

Theory and use of the instruments.
Determination of instrumental errors.
Determination of sidereal, apparent and mean solar time.
Transformation of different systems of co-ordinates.
Reduction of observations for refraction and parallax.
Determination of latitude and longitude.
Reduction of stars from apparent to mean place, and *vice versa*.
Theory of interpolation.

Combination of observations by the method of Least Squares.
Calculation and projection of eclipses.
Calculation of ephemerides.
Calculation of the orbits of comets and planets.

4. PHYSICS.

Instruction is given in Mechanics, Heat and Electricity, four times a week during the first two terms of the Junior year. "Deschanel's Natural Philosophy" is used as a text book, but is largely supplemented with lectures, explanations and problems. The subjects are treated both experimentally and theoretically. The students are required to take notes of the lectures and experiments, and of the solution of exercises, and these notes are at intervals inspected by the instructor.

The Mechanics included in the first part of this course serves not only as a good preparation for the subsequent parts of General Physics, but also as an introduction to Analytical and Applied Mechanics in the Engineering Course.

The work of the lecture room aims to make the principles clearly understood, both in their nature and their application, by the following methods:

1. By experimental illustrations.

2. By their use in the explanation of these illustrations, or of well-known phenomena.

3. By their application to the solution of numerous exercises of a practical character.

Quite an extensive supply of physical apparatus, to which additions are made as needed, permit a large variety of illustrative experiments. It is not the sole or chief aim in teaching this science to store the mind with facts, but rather to develop the reasoning powers and accustom the student to trace the connection between cause and effect. After grasping a general principle established by observation and experiment, he is exercised in deducing from the general law the numerous and varied consequences which, under stated conditions, flow from it. Students who wish to pursue further a special subject by experimental investigation under the direction of the instructor, have opportunity given as far as present means allow.

When desired by a sufficient number of students intending to teach Physics in public or private schools, a brief course of lectures will be given in the spring term on the methods of teaching, with special reference to such easy experiments and illustrations as may be given

with apparatus which can be constructed or obtained at very small expense. During the first two terms of the Senior year, the subjects of Light and Sound occupy two hours per week. Deschanel's book is used as a basis, and all necessary amplifications are introduced into the lectures, both from more extensive works and the current literature of the day.

The application of the Science of Heat to the warming and ventilation of houses, to the steam-engine and to the weather, is made by such illustrations as will tend to fix principles, as well as facts, permanently in the memory. The subject of Electricity is presented with equal fullness of detail in its relations to natural phenomena and modern industrial progress.

Throughout the whole course in Physics, care is taken to show the intimate connection of the various branches of science, and to give to the novelties of the day no more than a just share of attention. The concluding part of the course is devoted to such suggestions and directions as are calculated to stimulate to and guide in original work.

5. CHEMISTRY.

Inorganic, Organic, Applied, Analytical.

(a) *Inorganic Chemistry.*

INORGANIC CHEMISTRY is taught by text-book and lectures. The subject is introduced by experimental lectures on the volume-composition of substances. Then follows a careful black-board drill on the writing of empirical and constitutional formulas of acids, bases and salts. The elements are next taken up in lectures, followed by recitations. In all cases the aim is to illustrate *every point* experimentally, thus giving the student ample experience in rigid experimental demonstration. The students are required to take full notes on the lectures, and sketches of the apparatus used in the experiments. These notes are afterwards copied and handed to the Professor for examination, criticism and correction, thus training the student in accurate observation, and in facility and brevity of expression.

(b) *Organic Chemistry.*

ORGANIC CHEMISTRY is taught by lectures and recitations. Beginning with the determination of the molecular weight of organic compounds, the student is led to examine the principles of substitution, valence and structure of organic compounds. Starting out from Methane, the various members of the Methane (mono-carbon) series are derived. When this series has been completed, the Ethane series

is taken up and gone through with in the same manner. Then follow the Butane and Propane series, etc. At the end of each series a recapitulation of the typical reactions, and relations of each group is given.

The manner of treating the subject is substantially the same as that introduced by Prof. Hofmann, of Berlin. As the various substances are considered, their relations to vegetable and animal life and to agriculture are pointed out. Attention is also given to their practical applications, as in food, medicines, dyeing, and in manufactures generally. The lectures are accompanied by full experimental illustrations.

(c) *Applied Chemistry.*

The applications of Chemistry to the arts and manufactures are taught by text-book and lectures. Whenever it is practicable, the actual products are exhibited to the students, and the manufacturing processes reproduced in miniature. Attention is drawn to the scientific relations and connections between the various manufactures. The great losses by imperfect methods of manufacture and by waste products are pointed out, and the student is taught to see the true economy of production. Illustrative of the lectures, visits are made to various manufacturing establishments, of which there are a number in and about New Brunswick, and an opportunity is given to see the manufacturing operations in actual working.

(d) *Analytical Chemistry.*

Six rooms in the Geological Hall are at present devoted to chemical analysis.

Fifteen hours per week are devoted to this branch of Chemistry. An extensive stock of apparatus is kept on hand in the supply-room, so that the student is able to use the most modern appliances in his analyses.

In beginning the study of Blow-pipe Analysis, the student is first taught how to blow glass. He is then made familiar with the properties of the various chemical elements by performing their characteristic tests as laid down in the text-book. He then proceeds to analyze substances, or, in other words, to apply, for the detection of the elements, the characteristic tests he has learned. In this manner he soon becomes expert at detecting even traces of metals, etc. The small size of the apparatus, and the ease with which analyses are performed by its aid, make it an instrument of great value to the professional man, whether he be a mining engineer desirous of examining an ore in a part of the country where only a candle is obtainable, or a physician wishing to detect, in a few minutes, the

presence of arsenic, mercury or various other metallic poisons in a suspected substance.

In all cases the student works with his note-book at his side, and must note down his work as he proceeds. The analyses are reported immediately after their completion, in printed forms, and filed for reference. The aim of these reports is manifold. Students are compelled to write down a clear and concise account of their experiments. They learn to describe natural phenomena in explicit notes—a very useful and, for the scientific man, an absolutely indispensable acquirement. In reporting, they preserve the three great divisions of experimental science, *Experiment, Observation* and *Inference.* Their minds are developed by their continual use of practical logical deduction, in a way that only actual familiarity with experimental work can effect. The continual striving to express their ideas in a concise and logical form inculcates a thorough idea of system and business habits.

Determinative Mineralogy has been made a special branch of instruction. By the aid of the blow-pipe and a few chemicals, the student is soon able to determine the nature of any mineral or ore.

The examinations in Blow-pipe Analysis having been successfully passed, the study of Qualitative Analysis is entered upon. Here a far more complicated set of apparatus and chemicals is needed. While Blow-pipe Analysis can detect only a limited number of substances, Qualitative Analysis includes all the elements. The student begins in the same manner as with the blow-pipe. He performs the characteristic test, and learns the manipulations. He soon enters upon actual analysis. From simple substances, he proceeds gradually to more difficult ones, until his analyses include the most complicated and difficult mixtures. Accompanying the practical work in the laboratory, full courses of lectures and recitations are given, by which the student is given a clear idea of the theory of the subject. The course concludes with examinations in the theory and practice of analysis. In connection with this study, the use of the microscope and spectroscope is also taught.

Quantitative Analysis now begins. While in his former studies the student has learned how to detect the constituents of a substance, he now learns how to determine their *amount.* Here he acquires the delicacy and accuracy of quantitative method, in which the slightest speck of matter represents a certain weight, and becomes familiar with the handling of costly instruments of precision. The student analyzes, at first, compounds of known and fixed composition. As soon as he has acquired the necessary skill and manipulation, he analyzes substances of variable composition, as feldspars, limestones, clays, slags, cast-iron, steels, ores, etc., iron, zinc, nickel, copper, lead, tin, arsenic and antimony, German-silver, bronze, type-metal, pig-lead, paints, waters, superphosphates, guanos, milks, sal-soda, acetate of lime, sugars, bone-black, coal, soap, petroleum,

flour, wine, poisons, &c. Lectures are given on the general theory of Quantitative Analysis, which explain minutely the methods in use. The students are required to hand in once a week a written method, with reference to the text-book, for the analysis of supposed mixtures. These papers are criticised and discussed by the Professor. In this way the student gains an exact and practical knowledge of the whole subject, and is never at a loss for a method in the analysis of a substance with which he has not had previous analytical experience.

Stoichiometry, the mathematic of chemistry, is taught by lectures and black-board exercises. A thorough drill is given in its applications in Quantitative Analysis and Applied Chemistry.

In the practical study of Analysis the student applies the theoretical principles of Chemistry which he has learned in his lectures on General Chemistry. The continual practice in detecting substances by their characteristic appearances under varying conditions, and the necessity in every case of rigid experimental proof, become habits applicable to all things in actual life, and give the student a drilling and foundation in practical logical deduction and induction that are of incalculable value to him.

Next year it is the intention to preface the work in Analytical Chemistry with a thorough course in Experimental Chemistry.

The student concludes his course in the laboratory by undertaking an original experimental investigation on some point connected with Theoretical or Applied Chemistry. It is here that his enthusiasm is fully aroused, and his determination and energy display themselves. He handles new substances, invents methods, originates expedients and learns the value and power of discovery.

In this field strenuous efforts are being made toward development, for by this advanced teaching the student can be made to think and act for himself, place confidence in his own powers, and raise himself by *original* thought and work in the profession he adopts.

The graduates of the Chemical Course have obtained excellent positions in manufacturing establishments.

There are now ten students engaged in Chemical Analysis, of whom five are special students and one a post-graduate.

6. English Language and Literature.

In the recently organized department of English, the students are required to study the history of the English language, the history of English literature, and a selection of English prose and poetry; and to write essays in literary criticism which call for the careful study of the best authors. This is supplemented by a course of systematic private reading prescribed for examination. It is impossible in the time allotted to this branch, in the short period of a college course, to conduct the student over the entire field of our literature. The

course can only aim to create a love for literature, train the student in the critical study of it, and impart so much of the literature itself as will enrich his mind with the best thought and his speech with the most expressive diction of our mother tongue.

The value of such a course is now fairly recognized, although the course is not found in very many institutions, especially of science, and of but recent introduction in those in which it has been admitted. Neither our own language nor literature can be safely left wholly to the student himself or to the incidental acquisition which is made in the use of our language in the other departments. A distinct and independent position in the course is necessary to the thorough and systematic study required to make it valuable. It is especially important in a scientific course, from which the ancient classics are excluded. The student is engaged upon the language he is to use in common life. The method of study is that employed in Latin and Greek. The meaning, derivation, history and cognate relations of words; the analysis of sentences and translation into equivalent forms; the exemplification of principles and rules of grammar as well as of logic and rhetoric, are insisted upon in the study. The course is introduced with "*Trench* on the study of words," followed by a study of classic texts. The language engrosses attention in the early stage of the study, the literature itself in the later. The acquisition of the literature is of equal importance with the linguistic training, and for that the English student from his more direct access to the literature through his mother tongue enjoys a great advantage over the student of the literatures of the dead languages. When we reflect that English is his own literature, and will form the staple of his reading and the occupation of his leisure in after life, the importance of laying the foundation in college becomes clearly apparent. No study will more ennoble and refine his taste, imagination and heart. It is pursued with this end in view. A few of the more important classics of the language are critically studied in the class-room, and essays in literary criticism on assigned subjects for private reading are required through the Sophomore year. The history of the literature is studied in connection with the study of the literature itself and is made to grow out of it. The Manual is used as a work of reference.

7. MILITARY.

In October, 1882, Second Lieutenant F. L. Dodds, Ninth United States Infantry, reported for duty in this department in compliance with orders from the Adjutant General of the Army. The object of the instruction in this department is to give that elementary knowledge which every good citizen should possess, that he may the better aid his country in time of need, and in so doing give such military training and exercise as will add to the health and physique of each

student, while contributing something to the general discipline of the College. Lectures have been given, illustrating campaigns under the old order of battle, the handling of men on the march and in camp, and a description of the parts and mechanism of the arms with which our regular troops are now equipped. In another year it is intended to place these improved arms in the hands of the students, when it is hoped that without trenching upon the ordinary college instruction, this department may turn out citizen-soldiers whose zeal and accomplishments shall be worthy of a State whose National Guard has recently won so brilliant a reputation in the competitive test at Yorktown.

8. NATURAL HISTORY.

The course in this department begins with the Freshman year, in which Physiology, Zoology, and Botany are taught. The several text-books are in all cases supplemented by illustrated lectures, and in the study of Botany by frequent field excursions for practical work in the analyzing and classification of botanical specimens. In the Junior and Senior years, these subjects are still further elaborated and studied in the sciences of Meteorology, Physical Geography and Geology. The course of instruction is planned so as to bring these objects of every-day observation to the continued attention of the students, to teach him the principles of classification and systematic study, and to show their important relations to the successful conduct of the practical affairs of life. The extensive collections of minerals, fossils, geological and botanical specimens, shells, birds, etc., are arranged for study in the Museum of Geological Hall.

The Museum of the College occupies the second and third stories of the Geological Hall. There is one large room, with gallery and store rooms, at the south end. The cases on the main floor are devoted to the exhibition of geological, mineralogical and metallurgical collections, with the exception of one case, containing zoological specimens, and a case of Indian antiquities. The gallery is reserved for the collections of birds and the botanical and conchological specimens.

According to the present arrangement, the cases on the east side on the main floor are occupied by suites of minerals for use in the study of mineralogy, the general collection of minerals and ores and metallurgical products. The cases are constructed so as to exhibit the larger and better specimens on shelves above; and with drawers below in which to store duplicates. The collection of minerals is good, and adequate to the needs of ordinary collegiate instruction in this department. There are many fine specimens from the New Jersey zinc mines and other mineral localities.

The paleontological and geological collections are in the west side cases. One case contains specimens which illustrate the formation and

structure of rock masses. In the others the arrangement is according to age, beginning with the oldest and passing on through the successive geological ages to recent time.

The central part of the room is occupied by two cases containing the Beck Cabinet of Minerals, two cases with typical specimens of the rocks and ores of New Jersey, and one case of beautiful quartz crystals from Ellenville, New York. The remains of a mastodon are placed in a case under the gallery at the north end of the room; at the opposite end are the large and well-preserved footprints in red sandstone, found at Montville, New Jersey.

The collection of native birds is in a case on the gallery. It comprises all the more common species of our State and this part of the Atlantic coast.

For the illustration of Botany, the Herbarium lately presented to the College by Alfred Cuthbert, of Franklin, Essex county, New Jersey, meets the wants of the course in this branch of Natural History. It contains about twelve hundred species, including the greater number of those occurring in New Jersey, besides a large number of New Mexican plants. The collection of woods which grow in the State occupies a wall case on the gallery.

The conchological cabinet is large and well arranged. It is exhibited in flat table cases running around the gallery.

The Museum has a large amount of material stored and not on exhibition, nor easily accessible on account of a lack of sufficient case room. The collections of rocks, minerals, ores, etc., which are at present practically useless for purposes of study on the part of the students, would add greatly to those already classified and exhibited in the main room of the Museum. In the department of Natural History there is urgent need of more material to illustrate Zoology and Ornithology. The Herbarium also should be made fuller, to embrace all the species and varieties of plants and woods growing in our Middle States at least.

Notwithstanding these gaps, the Museum is used more and more each year by students and professors, and the number of visitors also increases. It is open to visitors every week-day afternoon during term time, and at other times on application to the College janitor.

Valuable donations of specimens are occasionally received from friends and generous patrons. Among the more notable of such gifts during the past year, are: (1) the Herbarium from Alfred Cuthbert; (2) a collection of native birds mounted by Gerard Hardenbergh, and paid for in large part by James Neilson and Dr. Henry R. Baldwin; (3) a very fine cast of the Crustacean, STYLONURUS *excelsior*, a new species, from the Devonian rocks of Delaware county, New York, the gift of M. & W. Bruce, members of the College, Class of '84; (4) a collection of native war weapons and a horn-bill from the East India Islands, and given to the College by Mrs. Oswald Miller.

It is greatly to be desired that the many patrons and friends of the College who have given so generously to make the Museum both useful and attractive, will continue to favor it with their contributions, and that others will come forward and fill up the vacant spaces with collections which shall make the equipment of the College as good as any in the land and equal to the demands of science upon it.

9. THESES.

The students of regular four-year courses are required to hand in at the end of the third term of the Senior year theses on subjects connected with their studies. These theses embody also the results of independent work or investigation. Students in the special Chemical course are required to hand in at the end of each term a thesis on some subject assigned to them for study. At the end of the summer they prepare a journal of travel or observation, which embodies the description of any interesting scientific objects met with during the vacation.

The following abstracts of a portion of the theses read before the State Board of Visitors by members of the last graduating class, are thought likely to be of interest, both on account of their subject-matter and as specimens of the work done by our students:

"THE NIAGARA SUSPENSION BRIDGE."

By Geo. H. Johnson, B.S., '82.

After describing the most primitive form of suspension bridge, and enumerating the advantages of this style of bridge, Mr. Johnson proceeds as follows: It is only in recent years that suspension bridges have been constructed capable of supporting heavy loads. The Niagara bridge, built by John Roebling, C. E., is one of the most notable of these works. The bridge is nearly thirty years old and has acquired an international reputation. * * * The upper or railroad platform, and the lower or common road platform, constitute respectively the top and bottom of a deep lattice truss, forming a kind of rectangular tube, 24 feet broad and 18 feet high. This design contributed greatly to the stiffness of the bridge, both vertically and horizontally. * * * The bridge is greatly stiffened laterally by placing the cables in oblique planes approaching the platform. Some of the other characteristics of this bridge are the continuous girders which support the rails, and aid greatly in the distribution of loads; the 64 over-stays to aid the cables, the 56 river-stays to pre-

vent oscillations, and finally the automatic adjustment at one end of the truss.

The anchorage was made by sinking four shafts on each side of the river into the sold limestone rock that composes the surface stratum. All the eight shafts, with one exception, were made 54 feet deep below the railroad track. * * * The anchor plate is firmly bedded in the rock, and every joint of the chain rests on a cast-iron plate supported on a large cut stone, which is itself bedded on a larger stone. By this arrangement the enormous pressure is distributed throughout the masonry. The pressure on the New York side is resisted by 140,000 cubic feet of solid rock. The wings and anchorage on the same side contain 54,162 cubic feet of masonry. The total resisting weight at one end is, therefore, about 15,533 tons. The maximum live and dead load supported by the cables is only about 1,300 tons; *i. e.*, about one-twelfth the resisting weight at each end.

The towers are constructed of limestone. The least section of each tower is 64 square feet. The factor of safety for the towers is, therefore, computed to be 28.3. * * *

The following computations for the cables are made on the assumption that the curves are parabolic.

Let W = the total load = 1,300 tons.

Let y = versed sine of cables = 54 ft. for upper; 64 ft. for lower; 59 ft. for the average.

Let a = span = 821.33 ft. from center to center of towers.

Then H = horizontal tension on the cables = $\frac{Wa}{8y} = \frac{1{,}300 \times 821.33}{8 \times 59}$ = 2,262.15 tons.

R = longitudinal tension = $H\ (1+\frac{16\,y^2}{a^2})^{\frac{1}{2}}$ = 2,353.64 tons, or 1,176,821.6 ℔s. on each of the four cables.

Each cable contains 910 wires, each wire having an ultimate strength of 1,648 ℔s.

The factor of safety for the cables is, therefore, $\frac{4 \times 910 \times 1{,}648}{1176821.6} = 5.097$.

Let $y = \frac{1}{2}$ the span.

Let x = the deflection.

Let $s = \frac{1}{2}$ the length of the cable.

Then $s = (y^2+\frac{x^2}{4})^{\frac{1}{2}} + \frac{x^2}{4\,y}$ hyp. log. $\frac{y+(y^2+\frac{x^2}{4})}{\frac{x}{2}}$ = 417.84 ft. for the upper cables. Therefore, the whole length of the upper cables, regarded as parabolas, from center to center of towers = 835.68 ft. * * * The ultimate strength of each of the anchor chains is computed to be 5,952,000 ℔s. * * *

We will now examine the strength of the pins and heads of the bars in the anchor chains. Experiments made by Sir Charles Fox, and reported in the Proceedings of the Royal Society, Vol. XIV., p. 139, 1865, show that to obtain the full efficiency of the link, the bearing surface of the pin must be a little more than the smallest section through the link. Otherwise the eyes will elongate. In the anchor chains of the Niagara bridge, the bars are 7 inches in width, and $1\frac{3}{8}$ inches in thickness. The diameter of the pins is scant 3.5 inches. The eighth link from the anchor plate is composed of eight bars. The bearing surface of the pin is, therefore, $\frac{3.5\ \pi}{2}\ 8 = 14\ \pi = 43.98$ inches. Area of section through the link $= 8 \times 7 \times 1\frac{3}{8} = 77$ inches. Therefore, according to Sir Charles Fox, the heads are only about $\frac{4}{7}$ as strong as the links.

If this estimate is correct, we have the factor of safety for the chains $= \frac{4}{7}$ of $5.09 = 274$, which is too small for safety. As the strength of the whole is limited by the strength of the weakest part, the pins should have been made larger or the cables smaller, in the ratio of 4 : 7.

When the anchor chains were examined in March, 1877, it was found that the eyes were elongated, and the pins bent. It was accordingly recommended that the anchorage be reinforced. This work was executed at large expense and at the risk of destroying the adjustment of the cables. * * *

Each cable has an independent saddle, which is mounted on ten rollers of cannon metal. Each roller is five inches in diameter and sustains a constant weight of 25 tons; this is increased to 33 tons for a maximum load. * * * A very high, steady wind displaces the bridge five or six inches to the leeward. To resist this movement there are the river-stays and the inclination of the planes of the cables. There are 64 over-stays extending from the saddles to points in the truss, twenty feet apart. Their ultimate strength is thirty tons each. Their supporting capacity equals their strength multiplied by the sine of the angle of their inclination to the horizontal. The average value of this trigonometrical factor for all the stays is about four-tenths. Taking five as the factor of safety, the supporting capacity of all the stays is, therefore, $\frac{64 \times 30 \times .4}{5} = 153.6$ tons.

There are 314 suspenders attached to each floor at intervals of five feet. They are made of wire rope, the same size as the over-stays, *i. e.*, 4.5 inches in circumference. They are attached to the floor beams by *U*-shaped stirrups. Taking no account of the overstays, the suspenders sustain a maximum weight of 1,300 tons, or 2.07 tons to each. The factor of safety is, therefore, $\frac{30}{2.07} = 14. +$

The change of length in the cables resulting from a change in temperature of 75° F. is computed to be .6303 feet. The change of deflection caused by this change in length is computed to be 1.645 feet. The depression produced in the center of the bridge by a live load of 300 tons is computed to be .63 feet, which agrees very nearly with observation.

Similar computations were made on the assumption that the cables were catenaries.

"THE MISSISSIPPI JETTIES."

By Solomon Le Fevre, B.S., '82.

The Mississippi river drains a section of country having an area of over a million square miles, about one-third as large as the continent of Europe. Until within a few years past the river was so obstructed at its mouth that it did not afford an adequate outlet to the commerce of the valley. All its mouths were blocked up by bars, which rendered entrance to the river dangerous, or, at least, very uncertain to vessels drawing more than thirteen feet of water. It was exceptional if a vessel passed the bar without detention.

In 1859 the committee who went to examine into the amount of detention found 3,700 tons of freight waiting to get over the bar.

Any system of improvement then which would remove all obstructions from the mouth of the river would be a great advantage, not only to the Mississisippi valley, by the impetus it would give to the development of its resources, but to the whole country, by increasing its commercial prosperity.

The first attempt to improve the channel was by dredging. But as a means of obtaining a permanent channel this was a failure.

Two methods were then proposed, each of which was earnestly advocated by its supporters. One was to build a ship canal from below Fort St. Philip, eastward through the bank of the river into the deep waters of the gulf. This plan was advocated by Gen. Humphrey, Chief of Engineers, U. S. A.

The other was to improve one of the passes of the river by means of jetties.

Capt. James B. Eads, of St. Louis, was the earnest advocate of the jetty system. He proposed to Congress to undertake the work at the sole risk of himself and his associates, receiving no payment from the government until certain depths of channel had been secured and maintained. The Board of Engineers appointed to decide as to the best method of improvement, whether by a canal or jetties, reported in favor of jetties, but recommended that South Pass be improved instead of Southwest Pass, as proposed by Capt. Eads. An act of Congress, approved March 3d, 1875, authorized Eads to proceed with the work. He was to receive $5,250,000 for the whole work.

The passes at the mouth of the river are formed as follows: Friction on the banks slackens the current and causes a deposit. This goes on until the banks become so steep that any further deposit slides down to the center and is again caught up by the more rapid current there, and until the pass is so contracted that it gives the water sufficient velocity to carry all its sediment along. When it reaches the mouth of the pass the water expands, its velocity slackens, and a deposit takes place on the sides. Thus the banks of the pass are built out into the gulf.

The momentum of the river water carries it a considerable distance into the salt water. It is gradually checked by expansion and friction, its sediment is dropped, and a bar is formed. The bar at South Pass is two and a quarter miles from the end of the banks, at Southwest Pass it is seven and a third miles. These distances have been the same since the first records, showing that these are the distances required to check the velocity sufficiently to deposit the sediment in a bar.

Now as the banks are generally extended the current cannot be so quickly checked and the bar must move out. At South Pass the banks advance 100 feet yearly and the bar moves out an equal amount.

Capt. Eads observed the phenomena carefully and reasoned thus: If by artificial means the banks of the river can be extended over the crest of the bar, and the whole volume of the pass be discharged directly into the deep waters of the gulf, having the same velocity it has through the pass, the bar must be removed. And as the current cannot be checked sooner a new bar cannot form nearer than two and a quarter miles from the jetty ends. At that distance the sediment will be scattered widely by gulf currents, or at any rate, the water being several hundred feet deep, the bar cannot reform in a long time and it may take centuries. In order to put his theory to the test Capt. Eads formed the South Pass Jetty Company, and commenced work June 14th, 1875. The plan was to construct the jetties of mattrasses of willow, similar to those used in Holland on the Mass. The bottom being an alluvial deposit would not support any heavier works. The under mattrasses were from 40 to 50 feet wide, according to the depth of water, and each one above narrower by about five feet. The bushy ends of the willows were left projecting on the channel side of the jetties, and these soon collected the sediment so that a uniform slope was produced with scarcely a trace of the willows.

Now let us look at the results obtained by the jetties. In May, 1875, that is just before the jetties were commenced, the distance between the curve indicating a depth of twelve feet inside the bar, and the same curve on the seaward side was 4,300 feet, and for a greater part of this distance the depth was only eight feet. In April, 1876, there was a channel 15 feet deep through the jetties; in March, 1879, a depth of 26 feet, and in July, 1879, a depth of 30 feet was found.

To form this channel 5,500,000 cubic yards of earth were removed by the force of the current.

Nor was the prophecy of the opponents of the jetty system fulfilled, that the formation of the bar in advance of the jetties would be so much accelerated. I have represented on the map the curves showing depths before the jetties were built, in red, and those showing depths afterward, in blue. The curves in the gulf in front of the jetties have changed their position very little. Some of them, instead of advancing seaward, have receded towards the jetty ends. This proves that if the bar re-forms it will be very slowly.

Out near the sea-ends, where they were greatly exposed to storms and where there was not much deposit to protect them, the jetties were surrounded by a crib-work of palmetto logs filled with stones, while over all were placed large blocks of concrete, made of stones, gravel and cement. These were carried down on a small railroad built over the jetties, and dropped directly into place.

The jetties are a complete success. They have accomplished everything that it was claimed they would. They furnish a channel, easily navigable, having a depth of thirty feet. This makes New Orleans easily accessible to the largest ocean-going steamers, and the shipments of grain from that port were increased twenty-five-fold within three years.

The whole responsibility, whether failure or success attended his efforts, rested upon Captain Eads, and his success gives him the honor of constructing the greatest river improvement in the world.

"THE DELAWARE BREAKWATER."

By F. W. Bennett, '82.

Breakwaters are structures designed to break the force of the waves, in order to make behind them a secure anchorage for vessels. Of late years the term has been restricted to those works of this character which are made of stone, laid either in courses or placed promiscuously, and which are situated in open roadsteads and are wholly isolated from the shore.

Taking the restricted sense, the first and most important breakwater is the one at Cherbourg, France.

The next breakwater in the order of time and importance is the one across the entrance of Plymouth Sound, in England. Sir John Rennie designed it, and from the experience derived at Cherbourg, was enabled to make great improvements on this latter structure, though it is on the same general plan.

There are no more difficult or interesting problems in engineering than the construction of breakwaters involve. The tremendous force of the waves, the tides and currents and drifting sands all raise questions in regard to position, form and materials which need thorough study.

The two works we have already noticed are on the *pierre perdue*, "long slope" or rip-rap system. It has been found that below a depth of about fifteen feet the influence of the waves does not extend. Hence, below this limit material assumes its natural slope of about one to one, but above this to high water level it assumes a slope of five or six to one, thus taking an enormous amount of stone. Where it is abundant this is not so much of an objection, but in other cases it will add greatly to the expense. A vertical wall would take much less material, but is more expensive to build. Such a breakwater is in process of construction at Dover, England.

It would thus seem that a breakwater constructed on the rip-rap system up to fifteen feet below low water and then having a nearly vertical wall extending from thence to high water level would make a minimum of expense. This has been proved by actual calculation by Capt. Barnard, U. S. A., in the case of the Delaware Breakwater.

Besides taking less material, a vertical wall seems to be better able to perform the required work. From the best testimony, it has been established that waves in deep water have nearly an oscillatory motion and not one of translation. As the water becomes shallow, however, they acquire a translatory movement. The vertical wall rising directly from deep water has only the oscillations to resist, while a long slope occasions a gradual shoaling of the water, and a breakwater built on this principle has to resist both motions.

Having now glanced at some of the most important European breakwaters, and the principles which are used in their construction, we come to consider particularly the Delaware Breakwater, the most important work of the kind in our country and one of the most important in the world.

In 1828, Congress appointed a commission to secure an eligible site and to prepare plans and estimates for a harbor near the entrance of the bay. They reported in favor of Cape Henlopen and recommended two works, the breakwater proper, and the ice-breaker, the former to commence 500 yards from the point of the cape, and to extend 1,200 yards in a W. N.W. direction. The ice breaker to extend W. by S. one-half S. 500 yards, having an interval between the two of 350 yards.

In 1828, only the two works we have alluded to had been built. Without attempting any improvements, the commissioners blindly copied the plans for the breakwater after them, taking the slopes from the Cherbourg and reducing the width on top eight feet from that of the Plymouth, which is thirty feet, and even this seemed to them a great step. In the opinion of Maj. Barnard even twenty-two feet was much too wide, and twelve would have answered.

In 1829, work was commenced on the breakwater, and by 1834 had advanced so far that vessels sought shelter behind it. In 1839, it had been considerably more than half completed, but from that time till 1864 little was done, and it was left in its uncompleted con-

dition. In 1869 it was finished, as we now find it. Its dimensions are as follows: Breakwater, length on top, 2,558 feet; ice-breaker, 1,359 feet; average width of both on top, 22 feet; at the base, 160 feet. They rise 14 feet above mean low water.

The total cost of the Delaware Breakwater has been $2,723,505.33, 19 per cent. of which was for contingent expenses.

The Delaware Breakwater is built on the rip-rap system. The stones vary on the inside from one-quarter to three tons in weight, and on the seaward slope from one and a half to seven and a half tons. They were brought in vessels from the most convenient quarries, a part being trap from the Hudson and the remainder gneiss and greenstone from Delaware. They were unloaded by means of cranes and deposited on the work. Above low water level it has been faced with rough blocks, set at right angles to the slope and wedged tightly together.

Built at a time when the commerce of the country was comparatively small, the breakwater was then adequate to protect all vessels seeking shelter behind it, but at present the wonderful growth of our country has so increased the amount of shipping that it is totally unable to shelter it all.

Besides this, causes have been at work which have greatly diminished the usefulness of the harbor. Shoals have been formed within it to such an extent that it only provides safe anchorage for the smaller class of vessels. These shoals have been growing since the work was commenced. In many places the water has diminished six feet in depth.

How to increase the available harbor space and the depth of water are problems which need consideration.

Some improvements are absolutely necessary, for at present a large fraction of the vessels needing shelter cannot get it in the harbor, either on account of the insufficiency of space or the shallowness of the water. It would seem that either these improvements would have to be made or a new breakwater constructed.

10. THE AGRICULTURAL DEPARTMENT AND STATE FUND.

The operations of the Agricultural Department during the past year are set forth in the accompanying report of the Professor in charge, and the lectures on Agriculture in several counties have been given as called for.

The amount of money received from the State Treasurer for the fiscal year ending October 31st, 1882, is six thousand nine hundred and sixty dollars ($6,960), which has been expended, as the law requires, exclusively for the salaries of Professors in the Scientific School. Respectfully submitted,

MERRILL E. GATES,
President of the Board of Trustees.

RUTGERS SCIENTIFIC SCHOOL.

COURSES OF STUDY.

COURSES OF STUDY.

Four distinct courses of study are included in the schedule which follows:

I. A Course in Civil Engineering and Mechanics.

II. A Course in Chemistry and Agriculture.

III. A Special Course in Chemistry.

IV. A Special Course in Agriculture.

During the first year the studies of the two full courses are the same, and are designed to furnish a suitable introduction to the pursuit of the higher branches in either.

During the last three years, the subjects of Higher Mathematics, Mechanics and Engineering, in the Engineering Course, are replaced by Analytical Chemistry, practice in the Laboratory, and Agriculture in the other. The remaining subjects are pursued by the students of both courses together.

The course of study for the first year in this Department is arranged so as to be complete in itself. It is especially designed to meet the wants of those who cannot take the entire four years' course, but who desire to fit themselves as land surveyors. Students leaving at this period of the course receive from the Faculty a certificate of their attainments.

Students in this Department have daily practice in Draughting with exercises and problems in Geometrical Constructions, in Descriptive Geometry, Topographical, Mechanical and Architectural Drawing, and in Graphical Statics. Students who acquire sufficient skill sometimes obtain positions as draughtsmen in various offices in the city during their course.

Special students are received, and allowed to take any part of the above course, provided their previous education is sufficient; and particular provision is made for them, especially in the Laboratory, in Mathematics, Surveying and Draughting.

The Special Courses in Chemistry and Agriculture occupy two years. The Laboratory is open from 9 A. M. until 5 P. M.

Students are instructed in Blow-pipe Analysis; Determinative Mineralogy; Analysis of Ores, Minerals, Coals, Waters, Technological Products, etc.; Analysis of Soils, Fertilizers, Agricultural Products and Foods; Detection of Poisons; Analysis of Urine and Animal Products and Microscopical and Spectroscopical examinations. The course of study depends to some extent upon the student's future pursuit in life.

MILITARY TACTICS.—In accordance with the requirements of the law, provision is made in this Department for the study of Military Tactics.

Special provision is also made for students who desire, after completing the regular course of study, to take post-graduate studies.

In connection with the instruction in Agriculture in this Department, the Trustees maintain an extensive model farm, designed to illustrate the principles of Agriculture, and also to test by experiment the value of different systems. It is under the charge of the Professor of Agriculture, and certain days during term time will be devoted to giving upon the farm explanations of the experiments and their results, to the students of the Chemical and Agricultural courses, as well as to any farmers who may desire to avail themselves of this privilege.

COURSES OF STUDY.

FRESHMAN YEAR.

Exercises during the year in Composition and Declamation. Bible-Class Sabbath morning.

FIRST TERM.

1. French.
2. Mathematics—Loomis' Algebra completed; Geometry.
3. Natural History—Dalton's Physiology; Lectures.
4. Rhetoric—Kellogg; Lectures.
5. Draughting—Practical Plane Geometry.
6. English Literature—Hales' Longer English Poems.

SECOND TERM.

1. French.
2. Mathematics—Geometry completed, Trigonometry, Plane and Spherical, Loomis.
3. Natural Philosophy—Lectures.
4. Elocution—Lectures.
5. English Literature—History of the English Language; Study of Words, Trench.
6. Draughting—Coloring, Topographical Signs, &c.

THIRD TERM.

1. French.
2. Mathematics—Surveying, Murray.
3. Natural History—Gray's Botany; Lectures.
4. English Literature—English Authors and Manual.
5. Draughting—Mapping, with sections, &c.

SOPHOMORE YEAR.

Course in Civil Engineering and Mechanics.

Exercises during the year in Composition and Declamation. Bible-Class Sabbath morning.

FIRST TERM.

1. Railroad Curves—Henck's Field Book.
2. Descriptive Geometry—Church.
3. Chemistry—Barker; Lectures; Stoichiometry.
4. German.
5. History—Freeman's Outlines.
6. Draughting—Practical Geometry, Solid.
7. Essays in Literary Criticism.

SECOND TERM.

1. Descriptive Geometry—Church; Construction of Problems.
2. Analytic Geometry—Bowser.
3. Chemistry—Barker; Lectures.
4. German.
5. History—Freeman's Outlines.
6. Draughting—Intersection of Surfaces, &c.
7. Essays in Literary Criticism.

THIRD TERM.

1. Analytic Geometry—Bowser, Completed.
2. Shades, Shadows and Perspective—Church; Construction of Problems.
3. Chemistry—Barker; Lectures.
4. German.
5. History—Creasy's Constitutional History of England.
6. Draughting—Linear Perspective, &c.
7. Essays in Literary Criticism.

SOPHOMORE YEAR.

Course in Chemistry and Agriculture.

Exercises during the year in Composition and Declamation. Bible-Class Sabbath morning.

FIRST TERM.

1. Blow-pipe Analysis—Nason.
2. Qualitative Analysis—Douglass and Prescott; Lectures; Laboratory Practice.
3. Descriptive Geometry—Church.
4. Chemistry—Barker; Lectures; Stoichiometry.
5. German.
6. History—Freeman's Outlines.
7. Draughting—Practical Geometry, Solid.
8. English Literature—Authors; Essays in Literary Criticism.

SECOND TERM.

1. Qualitative Analysis—Douglass and Prescott; Lectures; Laboratory Practice.
2. Descriptive Geometry—Church; Construction of Problems.
3. Chemistry—Barker; Lectures.
4. German.
5. History—Freeman's Outlines.
6. Draughting—Intersection of Surfaces, &c.
7. English Literature—Authors; Essays in Literary Criticism.

THIRD TERM.

1. Qualitative Analysis—Douglass and Prescott; Lectures; Laboratory Practice.
2. Shades, Shadows and Perspective—Church; Construction of Problems.
3. Chemistry—Barker; Lectures.
4. German.
5. History—Creasy's Constitutional History of England.
6. Draughting—Linear Perspective, &c.
7. English Literature—Authors; Essays in Literary Criticism.

JUNIOR YEAR.

Course in Civil Engineering and Mechanics.

Exercises during the year in Composition and Original Declamation. Bible-Class Sabbath morning.

FIRST TERM.

1. Mental Philosophy—Porter's Elements of Intellectual Philosophy; Lectures.
2. Differential Calculus—Bowser.
3. Physics—Deschanel.
4. Political Economy—Bowen and Perry.
5. Draughting—Lettering, &c.

SECOND TERM.

1. German.
2. Differential Calculus—Completed; Integral Calculus—Bowser.

SENIOR YEAR.

Course in Civil Engineering and Mechanics.

Exercises during the year in Composition and Original Declamation. Bible-Class Sabbath Morning.

FIRST TERM.

1. Mechanics—Tate, or Wood.
2. Engineering—Mahan.
3. Organic Chemistry—Pinner-Austen; Lectures.
4. Moral Philosophy—Calderwood; Lectures.
5. Physics—Deschanel.
6. Draughting—Machinery and Architecture.

SECOND TERM.

1. Engineering—Mahan.
2. Mechanics—Tate, or Wood; Bridge-Building, Wood.
3. Organic Chemistry—Pinner-Austen; Lectures.
4. Moral Philosophy—Butler's Analogy.
5. Physics—Deschanel.
6. Geology—the last four weeks of the term.
7. Draughting—Engineering.

THIRD TERM.

1. Engineering — Bridge-Building and Railway Practice; Geodesy.
2. Geology—Lectures.
3. Moral Philosophy—Butler's Analogy.
4. Draughting—Thesis.

SENIOR YEAR.

Course in Chemistry and Agriculture.

Exercises during the year in Composition and Original Declamation. Bible-Class Sabbath morning.

FIRST TERM.

1. Applied Chemistry—Wagner; Lectures.
2. Organic Chemistry—Pinner-Austen; Lectures.
3. Principles of Agriculture—Lectures.
4. Analytical Chemistry—Quantitative Analysis, Fresenius, Cairns; Lectures; Laboratory Practice.
5. Moral Philosophy—Calderwood's Handbook; Lectures.
6. Physics—Deschanel.
7. Draughting.

SECOND TERM.

1. Applied Chemistry—Wagner; Lectures.
2. Agriculture—Its Methods and Products.
3. Organic Chemistry—Pinner-Austin; Lectures.

4. Analytical Chemistry—Quantitative Analysis; Fresenius; Cairns; Lectures; Laboratory Practice.
5. Moral Philosophy—Butler's Analogy.
6. Physics—Deschanel.
7. Draughting.
8. Geology—Last four weeks of the Term.

THIRD TERM.

1. Agriculture—Animal Physiology; Care and Management of Domestic Animals.
2. Geology—Lectures.
3. Moral Philosophy—Butler's Analogy.
4. Chemical Investigations.
5. Draughting.
6. Thesis.

SPECIAL COURSE IN CHEMISTRY.

FIRST YEAR.

First Term.—1. Inorganic Chemistry. 2. Stoichiometry. 3. Blow-pipe Analysis. 4. Qualitative Analysis. 5. French. 6. Physics. 7. Thesis.

Second Term.—1. Inorganic Chemistry. 2. Qualitative Analysis. 3. Physics. 4. French. 5. Thesis.

Third Term.—1. Inorganic Chemistry. 2. Qualitative Analysis. 3. French. 4. Thesis.

Journal of Travel or Observation.

SECOND YEAR.

First Term.—1. Organic Chemistry. 2. Quantitative Analysis. 3. Stoichiometry. 4. Applied Chemistry. 5. Physics. 6. German. 7. Thesis.

Second Term.—1. Organic Chemistry. 2. Quantitative Analysis. 3. Applied Chemistry. 4. Physics. 5. German. 6. Thesis.

Third Term.—1. Geology. 2. Applied Chemistry. 3. Mineralogy. 4. German.

SPECIAL COURSE IN AGRICULTURE.

FIRST YEAR.

First Term.—1. Algebra. 2. Geometrical Problems. 3. Inorganic Chemistry. 4. Physiology and Zoology. 5. Analytical Chemistry.

Second Term.—1. Geometry. 2. Coloring and Topographical Drawing. 3. Analytical Chemistry. 4. Book-keeping.

Third Term.—1. Trigonometry. 2. Mapping. 3. Analytical Chemistry. 4. Botany. 5. Farm Accounts. 6. Mineralogy.

SECOND YEAR.

First Term.—1. Surveying. 2. Projections. 3. Physics. 4. Study of Domestic Animals. 5. Systematic Agriculture. 6. Analitical Chemistry.

Second Term.—1. Navigation and Nautical Astronomy. 2. Architectural Drawing. 3. Physics. 4. Geology. 5. How Crops Grow.

Third Term.—1. Leveling and Road Making. 2. Machine Drawing. 3. Meteorology. 4. Botany. 5. How Crops Feed.

Composition and Declamation throughout the whole course.

The hours of lectures or recitations are four each day, besides work in the Chemical Laboratory.

Students who pass their regular examinations in the above subjects, will, at the close of their course, receive certificates of their attainments. And at the end of two or more years further, if they shall have pursued practical agriculture on a farm, and shall then pass satisfactory examinations in prescribed subjects on Agricultural principles and practice before a Board of Examiners of the Scientific School, they shall receive Diplomas in Agriculture.

ENTRANCE EXAMINATION PAPERS.

The following specimens of some of the entrance examination papers of last year are here inserted with the view of indicating the standard of scholarship necessary for admission:

ENTRANCE EXAMINATION IN DESCRIPTIVE AND PHYSICAL GEOGRAPHY.

1. Bound Alabama.
2. Locate Japan.
3. Mention the capitals of the Middle States.
4. Mention and locate some peninsulas.
5. Mention the principal rivers of Europe.
6. What is a water-shed?
7. What is meant by the axis of a country? Illustrate.
8. Mention some deserts and explain the reasons for their arid condition.

ENTRANCE EXAMINATION IN ENGLISH GRAMMAR AND SPELLING.

1. Into what classes are the letters of the English alphabet divided, and what are the powers of the letters?
2. Give some account of the following terms: Syntax, consonant, analysis, mood, participle.
3. State the rule for the formation of the plural and possessive in compound words.
4. In what cases is the pronoun "that" to be referred to "who" and "which"?
5. How are verbs divided with respect to their form and signification?
6. Name and define the moods of the verb?
7. What is the usage of "will" and "shall" in the expression of simple futurity?
8. How are participles distinguished from participial nouns?
9. Criticise the expression "is being built" and "he lived a virtuous life."
10. What tense is used for propositions always true?
11. What is a sentence, and what are its principal parts?
12. What is a phrase?
13. What is a simple, a complex and a compound sentence?
14. Analyze and punctuate the following sentence and parse the words:

The pleasures of sense resemble a foaming torrent which after a disorderly course speedily runs out and leaves an empty and offensive channel.

15. Criticise the syntax of the following sentences. State whether true or false and give reasons and rules:

I am afraid lest I have labored in vain.
I would rather have been informed.
What is the cause of the leaves curling?
I was afraid that I should have lost the parcel.
Was the master or many of the scholars in the room?

He will maintain his cause tho' he lose his estate.
Please excuse my son's absence.
The house is situated plesantly.
If I can contribute to your and my Country's good.
Everyone partakes of honor bestowed upon the worthy.
Our deepest knowledge is knowing ourselves.
He has no other merit but that of a compiler.
You see how that not many are required.

16. Name and define the figures of Etymology.
17. Give the principal English feet.
18. Scan the following:

Restless mortals toil for nought
Bliss in vain from earth is sought.

At the close of the day when the hamlet is still
And mortals the sweets of forgetfulness prove.

18. Spell seventy-five words as dictated.

ENTRANCE EXAMINATION IN MATHEMATICS.

Arithmetic.

1. Add $\frac{1}{9}$, $2\frac{7}{8}$, $\frac{45}{94\frac{7}{11}}$ and $\frac{47\frac{5}{9}}{314\frac{3}{5}}$ together.

2. Divide .2844622 by 8,342.

3. Bought 39 acres, 2 rods, 16 perches of land for $3.75 per square rod, and sold it for $0.25 per square foot. What did I gain by my bargain?

4. Find the least common multiple of 362, 579, 832 and 221.

5. In what time will $480, at $4\frac{1}{2}$ per cent., amount to $561.60?

6. Extract the cube root of 17 to 3 places of decimals.

7. Find the number of dekalitres in 4,923 quarts, dry measure.

8. Find the number of kilograms of water, at max. density, in 4.4092 pounds, avoirdupois.

Algebra.

1. Divide $x^{\frac{3}{2}}+x^{\frac{1}{2}}y-xy^{\frac{1}{2}}-y^{\frac{3}{2}}$ by $x^{\frac{1}{2}}-y^{\frac{1}{2}}$

2. Add $\frac{1}{3\,(1-x)}$ and $\frac{2+x}{3(1+x+x^2)}$ together.

3. Given $x-\frac{y-2}{7}=5$, and $4\,y-\frac{x+10}{3}=3$, to find the values of x and y.

4. Add $\sqrt{24}$, $\sqrt{54}$, and $\sqrt{96}$, after simplifying the radicals.

5. Given $\sqrt{x+a} = \sqrt{x} + a$, to find the value of x.

6. Given $x^2 + y^2 = 13$, and $x + y = 1$, to find the values of x and y.

7. Given $2\,x^2 + 3\,x\,y + y^2 = 20$, and $5\,x^2 + 4\,y^2 = 41$, to find all the values of x and y.

8. Given $x^2 + y^2 - x - y = 78$, and $x + y + x\,y = 39$, to find all the values of x and y.

9. Given $x^2\,y^2 = 180 - 8\,x\,y$, and $x + 3\,y = 11$, to find all the values of x and y.

10. Find two numbers, such that their sum, their product, and the difference of their squares, shall be all equal.

11. Find the sum of the first 6 terms of the series 6, $4\frac{1}{2}$, $3\frac{3}{8}$, &c.

Geometry.

1. The sum of the three angles of a triangle is equal to two right angles.

2. An inscribed angle is measured by one-half of the arc, intercepted between its sides.

3. Two similar polygons are to each other as the squares on any two homologous sides.

4. Divide a given line in extreme and mean ratio.

5. The area of a circle is equal to one-half the product of its radius by its circumference.

6. Similar segments are to each other as the squares or their radii.

REPORT FOR THE YEAR 1881-82,

OF THE

Farm of New Jersey Agricultural College.

BY GEORGE H. COOK.

FARM OF NEW JERSEY AGRICULTURAL COLLEGE.

REPORT FOR THE YEAR 1881–2.

BY GEORGE H. COOK.

THE WEATHER AND THE SEASONS.

The season of 1881 was notable for its long and severe drought. While the immediate effects of the drought were felt in the shortness of the crops and in the drying up of the fall pastures, it was thought that there would be some compensating advantages in the drawing up of saline matters from below and in storing them in the subsoil and soil. It is too soon to observe any beneficial results, although in general the crops have been better than they were in 1881. The winter of 1881–'82 was one of the warmest on record here. The mean temperature was 34.96°, or five degrees above the average for our winter. December was remarkably mild and without any cold waves. In January there was a depression on the 24th to 3° below zero, the minimum of the winter. February, like December, was mild and even. The total rainfall of the season was 12.94 inches, or about the usual depth. But the greater part of the moisture precipitated was in rain. The snows were light and the ground was bare throughout December and during much of January and February. The winter grain had grown well during the fall, and the absence of extreme cold favored it, so that when spring opened and the weather began to grow warm it looked well and started up at once. But the spring was wet and backward. March was three degrees only warmer than February, and there were cold days late in the month. The mean temperature of the spring was 3° below the average; that of May being 8° below its mean for many years past. The growth of all summer crops was slow in consequence of the cold season. The first part of June was more like May, and the average summer heat did not come until after the middle of the month. From that time on the summer was warm and dry. The rainfall of June

was much below the average; that of July was 3.04 inches; and the total for the calendar summer months amounted to 7.72 inches, or scarcely one-half the average quantity. The drought came earlier than in 1881 and was not so prolonged into the autumn, but it affected the corn and potato crops seriously. The winter grain and the oats were not hurt to any extent. The wheat harvest was favored by the dry weather. Near the end of August the season changed to cooler and wet weather. There were frequent rains throughout September, and the memorable equinoctial storm of the 21st to 24th inclusive, during which the rainfull amounted to 12.03 inches. But the rains came too late to revive the corn, and the yield of that crop was 50 per cent. below its average per acre. The potato crop, also, was short. The pastures came up wonderfully and there was an abundance throughout the autumn for all stock feeding upon them. The severe and heavy rains washed out the fields in many places and thus interfered with some early sowed grain. The overflows did much damage on low grounds exposed to freshets. The aggregate losses in this way were very large, particularly in the central part of the State. The autumn following this equinoctial storm was unusually mild and equable. There were frequent, though light rains. And the autumn rainfall was but little more than that usually received, although that for September was unprecedented in depth. First killing frost did not come until about the middle of November. The growing season was prolonged late and was a long one. The fall-sowed grain did well as the ground continued moist, notwithstanding the light rains of October and November. And the grass or fall pastures were in fine condition and afforded stock all they needed until the snow of the 29th covered them. The season may be said to have closed at that date.

TEMPERATURE AT COLLEGE FARM.

MONTHS.	1882.			1863-1870 & 1876-1882.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
January	48	-3	29.5	67	-12	28.4
February	55	15	35.5	67	-10	30.3
March	59	23	38.9	77	4	36.8
April	76	27	44.3	81	21	48 2
May	83	35	51.7	98	37	58.4
June	95	54	67.8	98	46	68.0
July	91	59	70.7	101	56	74.6
August	93	54	69 5	99	48	71.9
September	90	50	64.7	103	42	65.4
October	78	41	56.2	89	29	54.2
November	71	16	37.2	74	11	39.1
	1881.			1863-1870 & 1876-1882.		
December	61	19	39.8	65	-8	31.7
Year	95	-3	50.48	103	-12	50.58
Range		98			115	

RAINFALL AT NEW BRUNSWICK.

The rainfall (including melted snow) in the table here given is from the record kept by P. V. Spader, Esq. The average for the term, 1854–1882, is made from observations at the College to the end of 1867; the years since are from Mr. Spader's record.

MONTHS.	1854-1882.	1882.
	Inches.	Inches.
January	3 43	5.49
February	3.18	4 24
March	3 55	2.62
April	3.75	2.83
May	3.87	5.29
June	3.92	1.48
July	4.72	3.04
August	4.78	3.20
September	3.74	15.52
October	3.30	1.42
November	3.69	1.60
December	3.47*	3.92†
Year	45.40	50 65

*Not including December, 1881. †December, 1881.

CROPS.

Of the 97 4-10 acres in the farm there have been 92 acres in use. The remainder is occupied with roads, buildings, cattle and hog yards, and the fish-pond. The following are the crops which have been grown on the farm during the year:

	Acres.
Wheat	9.54
Rye	7.05
Oats	13.20
Corn	16.00
Sorghum	1.60
Potatoes	1.00
Clover and Timothy	31.00
Fodder-Corn	6.10
Pasture	5.76
Garden vegetables	0.75
	92.00

Turnips, second crop, one acre.

Wheat—The very dry weather at the time of sowing last year, prevented the germination of the wheat for several weeks, and when it sprouted it came up very unevenly. It was not supposed that we could have a half crop, but favorable weather in December gave it time for some unusual growth. On the whole field we harvested 259 bushels, which is at the rate of 27 bushels per acre. The variety grown was the Fultz.

The wheat ground was fertilized with nearly 300 lbs. of Lister's ammoniated superphosphate, drilled in with the seed.

Rye—This crop is grown either for green fodder, or else because the time of sowing is too late for wheat. A part of the past year's growth was cut and fed to cows green, another part was ensilaged, and is still to be tested for fodder—and only about two and a quarter acres were harvested for the grain. From this 78 bushels were threshed, which is at the rate of 34 bushels per acre. The growing rye which was first cut, sprouted again, and some of it headed out and ripened. The grain is small and the crop is not yet threshed out.

No manure was applied to the ground for the rye crop.

As green fodder the rye can be cut when the heads first appear, about May 10th, and the cutting can be continued until the straw is too hard for cattle to eat, which is early in June. The weight of the crop on very rich ground is from 3 to 9 tons per acre.

Oats—Last year's corn ground was sown with oats. The straw grew so large and heavy that much of it was lodged early, greatly to the damage of the crop of grain. The yield was 430 bushels, which is 39 bushels per acre.

There was no manure used in growing this crop.

Indian Corn—This was mostly planted on very flat ground, some of which was the best on the farm. The pinching drought came just as the corn was tasseling, when rain was most needed, and the crop was greatly damaged. The husked corn weighed 40,700 pounds, which at 80 pounds for a bushel is 509 bushels or 32 bushels per acre. The corn ground was manured from the barnyard.

Sorghum—This was grown simply for experimental purposes, and details of its cultivation will be found under the head of experiments.

Potatoes—This crop was better than common with us. 150 bushels were harvested from a single acre. The ground on which they were grown was in sod the preceding season, and was plowed after the mowing, and then a crop of turnips was taken off. The ground was well manured from the barnyard.

Clover and Timothy—The dry weather of 1880 was so severe as to kill the roots of much of our clover and timothy, and it would have been better to plough up most of the ground in meadow, if it had been possible. The whole crop of hay was not more than 30 tons or about a ton to the acre. No top-dressing was applied to the ground for this crop.

Fodder Corn—Most of this crop was consumed in soiling the cows. A portion however was cut, put in small shocks like ordinary corn shocks, and is now dry and ready to be cut and fed to cattle. Another portion was cut at the same time and then put through the machine for cutting and crushing it for ensilage, and it is now in the silo ready for feeding.

The ground was heavily manured for the fodder corn, and the crop was a good one, considering the drouth to which it was exposed. Something further will be said upon this topic under ensilage.

Turnips—After the potatoes were dug, the ground was ploughed and sown broadcast without further manuring, with turnip seed. Cowhorn and Yellow Globe turnips were grown and the crop was 225 bushels. The Yellow Globe crop was the best.

Pasture—This was of not much value except as a place of exercise for the cows, which were kept most of the time in stanchions, in the stables.

STOCK.

Forty cows are kept on the farm at this time. No attempt is made at present to breed fine stock. The means of the farm do not allow of it. A few Ayrshires are in the herd, but most of the cows are of the

native stock, though some are crossed with Shorthorn, Devon or other imported breeds. They are kept up in stables, and receive green fodder during the season of it.

Eighty thousand and three hundred and fifty-eight quarts of milk have been sold at wholesale in Jersey City during the year from December 1st, 1881, to December 1st, 1882. And have been retailed in New Brunswick 39,192 quarts in the same time.

A few pigs are kept, but not of any pure breed.

A pair of mules and three horses are kept for the use of the farm, and one horse for the delivery of milk in town.

EXPERIMENTS.

Oats—The one-tenth of acre plots on which Indian corn with special chemical fertilizers was grown last year, were again dressed with the same fertilizers as before and sown with oats in the spring of the present year. The following table shows the fertilizers used and the product of oats and straw per acre. The legal weight of thirty pounds being accounted a bushel.

TABLE—OATS.

Number of Plot.	FERTILIZERS. KIND.	Amount per Acre. Pounds.	Cost per Acre.	YIELD PER ACRE. Grain. Pounds.	Grain. Bushels.	Straw. Pounds.	Pounds per Bushel.
1	Nothing	.....	.....	925	31	1,675	31
2	Nitrate of Soda	150	$5 85	880	29	1,720	32
3	Superphosphate	350	5 25	1,080	36	1,820	32
4	Muriate of Potash	150	3 75	1,090	36	2,030	33
5	Nitrate of Soda Superphosphate	150 350 } 500	11 10	1,470	49	2,200	34
6	Nothing	.....	.....	1,150	38	1,600	32
7	Nitrate of Soda Muriate of Potash	150 150 } 300	9 60	1,350	45	2,100	34½
8	Superphosphate Muriate of Potash	350 150 } 500	9 00	1,460	49	2,090	35
9	Nitrate of Soda Superphosphate Muriate of Potash	150 350 150 } 650	14 85	1,730	58	2,770	35
10	Plaster	400	1 60	1,290	43	1,610	31½
11	Fine Barnyard Manure	20 2 horse loads.	30 00	1,750	58	2,850	35

This is the first trial of fertilizers for oats on the College farm, and it is not prudent to draw any general conclusions from them. From

this single trial it appears that none of the single fertilizers showed peculiarly marked effects,—neither did those in twos. The complete manure was equal to the barnyard manure, though it cost only half as much.

Indian Corn—The trials of various chemical fertilizers singly and in combination, in their effects upon the growth of Indian corn, have been repeated this year upon one-tenth of acre plots, the same as for several years past. The field in which the experimental plots were located, is one which was cleared and drained a few years since. The soil is undoubtedly of uniform composition, but some portions of it were a little lower than others, and had always been wetter when in forest, and when ploughed the soil was lighter colored in some spots. Since it was cleared it has had the same cultivation and manuring throughout. The soil under the influence of drought, however, has shown marked differences in quality. And the effects of the fertilizers have been modified more on some plots than on others by the lack of rain.

The following are the details of the fertilizers, their cost, and the product of corn and stalks per acre.

TABLE—INDIAN CORN.

Number of Plot.	FERTILIZERS. KIND.	Amount per Acre. Pounds.	Cost per Acre.	YIELD PER ACRE. Ears. Pounds.	Shelled Corn. Bushels.	Stalks. Pounds.
1	Nothing			2,150	27	3,050
2	Nitrate of Soda	150	$5 85	1,600	20	2,555
3	Superphosphate	350	5 25	1,700	21	3,050
4	Muriate of Potash	150	3 75	2,150	27	3,300
5	Nitrate of Soda Superphosphate	150 350 } 500	11 10	1,450	18	2,050
6	Nothing			1,300	16	2,050
7	Nitrate of Soda Muriate of Potash	150 150 } 300	9 60	2,050	26	2,850
8	Superphosphate Muriate of Potash	350 150 } 500	9 00	1,300	16	2,950
9	Nitrate of Soda Superphosphate Muriate of Potash	150 350 150 } 650	14 85	2,000	25	3,550
10	Plaster	400	1 60	1,300	16	2,500
11	Fine Barnyard Manure.	20 2-horse loads.	30 00	2,600	33	4,000

The result of this experiment is so modified by the want of rain during the most important time of its growth, that conclusions from

it cannot safely be drawn which would be applicable in the growing of corn in ordinary seasons. The single result which has been observed in all our experiments with fertilizers in corn growing for eleven years, is that the weight of stalks is increased by the use of muriate of potash. And it may be said that, as has been the case in former years, nitrogen in nitrate of soda or sulphate of ammonia does not increase the yield of corn.

Sorghum Sugar Cane—Experiments have been made in growing sorghum, in testing the influence of commercial fertilizers upon its growth, its production of sugar, its product of seed, and its value for ensilage.

Sixteen plots of one-tenth of an acre each were laid off in the late autumn of 1881, and one-half of each plot was ploughed and subsoiled. The remaining half plots were ploughed in the spring, but not subsoiled. The fertilizers were sown broadcast on the 16th of May, and the seed, which was Early Amber, was planted the same day. It was planted in rows $3\frac{1}{2}$ feet apart. The growth of the cane was remarkably good until the middle of August, when it was stopped by the severe drouth. The intense heat and drouth checked the growth suddenly, so that though ready to head out, it did not put forth the usual large and expanded heads, but those which were short and imperfectly developed. At the close of the season when rains came, side shoots were put out, but it was too late for the seed to mature. The whole crop was much short of an average, but the seed was more deficient than the canes.

When the seed was ripened and hard, the stalks were still juicy and sweet, and several tons were cut and crushed for ensilage. This appears to be keeping well, and feeding experiments will be made with it in the course of the winter.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	No Manure.	350 lbs. Superphosphate.	150 lbs. Nitrate of Soda.	150 lbs. Potassium Chloride.	350 lbs. Superphosphate. 150 lbs. Sodium Nitrate.	No Manure.	350 lbs. Superphosphate. 130 lbs. Potassium Chloride.	150 lbs Sodium Nitrate. 150 lbs. Potassium Chloride.	350 lbs. Superphosphate. 150 lbs. Potassium Chloride. 150 lbs. Sodium Nitrate.	400 lbs. Calcium Sulphate.	20 two-horse loads Barnyard Manure.	200 lbs. Potassium Sulphate.	350 lbs. Superphosphate. 200 lbs. Potassium Sulphate.	200 lbs. Potassium Sulphate. 150 lbs. Sodium Nitrate.	200 lbs. Potassium Sulphate. 150 lbs Sodium Nitrate. 350 lbs. Superphosphate,	200 lbs. Potassium Sulphate. 150 lbs. Sodium Nitrate. 700 lbs. Superphosphate.
Cost of Fertilizer per acre	.....	$5.25	$5.85	$3.75	$11.10	.....	$9.00	$9.60	$14.85	$1.60	?	$5.60	$10.85	$11.45	$16.70	$21.95
Pounds of Sorghum per acre	25980	25130	28280	33320	30160	29360	30450	31010	30710	25670	28740	25700	25290	23360	25900	29470
Pounds of Stripped and Topped Cane per acre	15874	15555	19344	21391	17583	16368	17509	16745	17351	15402	17905	15549	15073	14226	17145	19185
Tons of Stripped and Topped Cane per acre	7.93	7.78	9.67	10.70	8.79	8.18	8 75	8.37	8.68	7.70	8 95	7.77	7.53	7.11	8.70	8.59
Pounds of Extractable Juice in 100 lbs. of Stripped and Topped Cane	43.1	44.2	42.3	42.3	38.1	39.1	41.3	36.6	38.5	37.8	39.6	39.1	37 8	36.	42.2	41.8
Pounds of Extractable Juice in one acre of Stripped and Topped Cane	6842.	6875.	8183.	9048.	6699.	6400.	7231.	6129.	6680.	5822.	7090.	6460.	5697.	5121.	7235.	8019.
Pounds of Sugar in 100 lbs. of Juice	13.00	13.30	13.20	13.50	13.50	12.90	12.80	11.70	12.80	13.50	13.40	13.50	12.60	14.00	13.60	13.20
Pounds of Extractable Sugar per ton of Stripped and Topped Cane	112.0	118.0	112.	114.	104.	101.	106.	86	99	103	107	112	.95	101	122	123
Pounds of Extractable Sugar per acre of Cane	890	914.	1080	1221	904	826	926	717	855	786	950	872	718	717	984	1059
Co-efficient of Purity of Juice	74.7	76.1	74.8	77.	77.	74.1	76.	72.1	74.	76.1	76.	76.5	73.	77.5	75.	74.5
Pounds of Clean Seed per acre	675	730.	850	595	315	185	70	.....	90	275	310	385	350	480	655	560

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	No Manure.	350 lbs. Superphosphate.	150 lbs. Nitrate of Soda.	150 lbs. Potassium Chloride.	350 lbs. Superphosphate 150 lbs. Sodium Nitrate.	No Manure.	350 lbs. Superphosphate. 150 lbs. Potassium Chloride.	150 lbs. Sodium Nitrate. 150 lbs. Potassium Chloride.	350 lbs. Superphosphate. 150 lbs. Potassium Chloride. 150 lbs. Sodium Nitrate.	400 lbs. Calcium Sulphate.	20 two-horse loads Barnyard Manure	200 lbs. Potassium Sulphate.	350 lbs. Superphosphate. 200 lbs. Potassium Sulphate.	200 lbs. Potassium Sulphate. 150 lbs. Sodium Nitrate.	200 lbs. Potassium Sulphate. 150 lbs. Sodium Nitrate. 350 lbs Superphosphate.	200 lbs. Potassium Sulphate. 150 lbs. Sodium Nitrate. 700 lbs. Superphosphate.
Cost of Fertilizer per acre	.....	$5.25	$5.85	$3.75	$11.10	.....	$9.00	$9 60	$14 85	$1.60	?	$5.60	$10.85	$11.45	$16.70	$21.95
Pounds of Sorghum per acre	29840	28180	31670	27140	32020	29740	31750	36370	37420	30920	29700	24320	23330	26030	31560	32800
Pounds of Stripped and Topped Cane per acre	20768	18514	20712	16203	19372	19003	20669	24704	24116	19418	19335	15200	14418	17831	21808	22009
Tons of Stripped and Topped Cane per acre	10.38	9.25	10.35	8.10	9.68	9.50	10.33	12.35	12.5	9.71	9.66	7.60	7.21	8.91	10.90	11.
Pounds of Extractable Juice in 100 lbs. of Stripped and Topped Cane	45.8	45.8	49.	39.5	43.5	43.5	47.8	49.1	47.	45.5	50	42.5	40.5	43.7	44.6	43.1
Pounds of Extractable Juice in one acre of Cane	9512.	8479.	10149.	6400.	8427.	8266.	9880.	12140.	11331.	8835.	9668.	6080.	5839.	7792.	9726.	9486.
Pounds of Sugar in 100 lbs. of Juice	12.	12.5	12.3	11.9	12.	11.8	10.5	10.2	11.2	12 4	12.3	12.6	13 5	13.7	12 8	13 5
Pounds of Extractable Sugar per ton of Stripped and Topped Cane	110.	101.	120.	94.	104.	102.	100.	100	105	112	123	100	109	120	114	116
Pounds of Extractable Sugar per acre of Stripped and Topped Cane	1141.	1060	1248	762	1011	975	1037	1238	1269	1096	1189.	766	788	1068	1245	1281
Co-efficient of Purity of Juice	69.6	72	73	70	74	69	65	66	70	71	72	73	76	77	73	75
Pounds of Clean Seed per acre	1095	620	785	370	330	510	320	490	295	290	290	500	670	470	680	790

The results of these experiments are all modified and made in most respects worthless by the obviously different effects of drought on different parts of the same field.

The spring-ploughed ground produced a little more sorghum than that which was fall-ploughed. But the difference was not very marked, and the former may have had the advantage in growing on the lower slope of the rising ground.

The extractable sugar, though varying on the different plots, runs up as high as 1,200 pounds per acre; the weight of the stripped and topped cane as high as 12½ tons per acre, and the seed to near 20 bushels per acre.

The different fertilizers were applied in order to determine the effect upon the quantity of cane and seed, and the quantity, richness and purity of the juice, but they are unsatisfactory, for the lack of seasonable rains.

A much fuller account of these experiments will be found in the annual report of the New Jersey Agricultural Experiment Station for 1882.

Note on the fertilizers used in the field experiments—Nitrogen, phosphoric acid and potash are essential and expensive elements in commercial fertilizers. The amount of each of these as used in the different fertilizers applied in our experiments is as follows:

	Nitrogen.	Available Phosphoric Acid.	Potash.
	Pounds.	Pounds.	Pounds.
350 pounds Superphosphate contains	.....	52½	.....
150 " Nitrate of Soda "	22½	.....	.....
150 " Muriate of Potash "	.....	.....	75
150 " Nitrate of Soda, 350 " Superphosphate — contains	22½	52½	.....
150 " Muriate of Potash, 350 " Superphosphate — contains	.....	52½	75
150 " Nitrate of Soda, 150 " Muriate of Potash — contains	22½	.....	75
350 " Superphosphate, 150 " Nitrate of Soda, 150 " Muriate of Potash — contains	22½	52½	75
20 two-horse loads barn-yard manure contains	204	164	200
200 pounds Sulphate of Potash contains	.....	.....	80
350 " Superphosphate, 200 " Sulphate of Potash — contains	.....	52½	80
150 " Nitrate of Soda, 200 " Sulphate of Potash — contains	22½	.....	80
350 " Superphosphate, 150 " Nitrate of Soda, 200 " Sulphate of Potash — contains	22½	52½	80
700 " Superphosphate, 150 " Nitrate of Soda, 200 " Sulphate of Potash — contains	22½	105	80

New varieties of Wheat—Three varieties of wheat received from the Department of Agriculture were tested. They were named Champion Amber, Spark's Swamp and Finley. They were sown on plots of 30 square rods each, and were manured at the rate of 300 pounds of ammoniated superphosphate per acre. The Champion Amber looked better than either of the others, larger and broader leaves and taller stems. The Finley had precisely the appearance of Fultz wheat, and it is presumed to be the same.

The following is their yield per plot and per acre:

	Pounds.	Pounds per acre.	Bushels per acre.
Champion Amber	335	1,786	29.7
Spark's Swamp	350	1,867	31.1
Finley	402	2,144	35.7

The times of ripening are the same as that of our common Fultz wheat, and there is nothing either in their growth or quality, which is at all superior to the kind we are now cultivating.

GREEN FODDER CORN; DRIED FODDER CORN; ENSILAGE.

Two very important questions are considered in the following experiments: First, is the loss of food by fermentation, when green fodder corn is dried in stacks, greater or less than when it is preserved in a silo? Second, is ensilage more valuable for milk production than dried fodder corn?

To study these questions, an experiment was begun on the College farm on the first of September, 1881. At that time the corn was in the milk, the stalks were very rich in cane sugar and all conditions apparently were favorable for the trial.

The amount of available green fodder corn, by actual weight, was ten tons. Of this one-half was arranged in the field in fifty small stacks; while the other half, after it had been cut by horse power into lengths of three-sixteenths of an inch, was closely packed in a silo of about twelve tons capacity. The analysis of a sample taken with the utmost care to represent the entire quantity used in this experiment, gives the chemical composition of the corn before it was affected either by loss of moisture or by fermentation.

About the last of November, after an exposure to the weather of nearly three months, twelve hundred pounds of the dried stalks were passed through a *Lion Cutter and Crusher*, then thoroughly mixed and sampled. The analysis of this sample compared with that of the original green corn shows the changes which occurred during the process of field curing.

On the twenty-third of December, the contents of the silo were found to be in an excellent state of preservation. A sample taken eighteen inches from the surface was entirely free from disagreeable

smell, insipid to the taste, and as shown by the analysis equal in all respects to the best ensilage which has yet been received at this Station. The chemical composition of these three samples can be seen in the following table. It should be remembered that sample No. I. represents the green corn, while samples Nos. II. and III. represent fodders obtained from this corn by two different methods of preservation.

TABLE NO. I.

	No. I. Green Stalks.	No. II. Dried Stalks.	No. III. Ensilage.
Water	75.00	39.37	74.70
Ash	1.58	4 63	1.95
Proteine	1.25	3.84	1.75
Fat	.22	.66	.27
Fiber	6.35	18.65	7.86
Carbhydrates	15.60	32 85	13.47
	100.00	100.00	100.00

On account of the different amounts of water in these samples, their relative compositions are not plainly seen. Comparisons between them can be easier made by arranging the results in another table, in which the composition of 100 pounds of the dry matter of each sample is given. Table No. II. is computed for this purpose.

TABLE NO. II.

	No. I. Green Stalks.	No. II. Dried Stalks.	No. III. Ensilage.
Ash	6.32	7.64	7.71
Proteine	5.00	6.33	6.92
Fat	.88	1.09	1.06
Fiber	25.40	30.76	31.07
Carbhydrates	62.40	54.18	53.24
	100.00	100.00	100.00

The ash of corn stalks is that portion which cannot be destroyed by fire. It is not in the least affected by fermentation, nor is it probable that its total amount was in any way changed either after the corn was packed away in the silo or after it was stacked. It is therefore adopted as a standard in comparing the above analyses.

It has been shown that one hundred pounds of the green corn contained seventy-five pounds of water; four hundred pounds therefore

of this corn would have yielded one hundred pounds of dry matter containing 6.32 pounds of ash. The question now is, *what is the weight of dry matter in the ensilage and in the field-cured stalks which contains* 6.32 *pounds of ash?* A simple calculation from the figures in table No. II. gives the following results:

TABLE NO. III.

	No. I. Green Stalks.	No. II. Dried Stalks.	No. III. Ensilage.
Ash	6.32	6.32	6.32
Proteine	5.00	5.24	5.67
Fat	.88	.90	.86
Fiber	25.40	25.44	25.49
Carbhydrates	62.40	44.82	43.64
Total weight dry matter	100.00 lbs.	82.72 lbs.	81.98 lbs.

Eighty-two pounds of the dry matter of the ensilage and eighty-two and three-quarters pounds of the dry matter of the field-cured stalks now contain the same weight of ash which one hundred pounds of the dry matter of the green corn contained. *During the process of field curing, therefore, four hundred pounds of green corn lost seventeen and one-quarter pounds of dry matter; while four hundred pounds of green corn packed in a silo lost eighteen pounds of dry matter.* Table No. III. shows further that neither the field-cured corn nor the ensilage suffered a loss of proteine, fat or fiber, but that the total loss fell upon the class, carbhydrates, which includes sugar, starch, etc., the least costly ingredients of fodders.

Admitting now that quite as much of the dry matter of green corn was preserved, *in this experiment*, by field curing as by packing in a silo, there remains still several important questions to be considered. First, will cows eat the dried corn fodder as readily and with as little waste as they will eat ensilage? Second, how does the milk of cows which are fed dried fodder corn compare in quantity and quality with the milk of the same cows when ensilage is used?

A feeding trial was begun on the 6th day of December, for the purpose of studying these questions. Four cows were selected from the herd, placed side by side, fed, watered and exercised at the same time, and for sixty consecutive days treated in all respects as nearly alike as was possible.

During the first period of twenty days, all four cows were fed the same daily ration, made up for each 1,000 pounds of live weight of

	Fat.	Proteine.	Carbhydrates.
20 lbs. of Dried Fodder Corn, containing...	.10 lbs.	.57 lbs.	7.08 lbs.
3 lbs Winter Wheat Bran, containing.....	.10 lbs.	.40 lbs.	1.38 lbs.
30 lbs. Brewers' Grains, containing	.40 lbs.	1.58 lbs.	3.00 lbs.
Total Digestible Food.....	.60 lbs.	2 55 lbs.	11.46 lbs.

The digestibility of the dried corn is here assumed to be the same as green corn.

During the second period of twenty days, the daily ration for two of the cows was the same as during the first period; the other two were fed ensilage instead of dried fodder corn. For each 1,000 pounds of live weight this second ration was

	Fat.	Proteine.	Carbhydrates.
50 lbs. of Ensilage, containing.....	.10 lbs.	.64 lbs.	7.34 lbs.
3 lbs. Winter Wheat Bran, containing.....	.10 lbs.	.40 lbs.	1.38 lbs.
30 lbs. Brewers' Grains, containing.....	.40 lbs.	1.58 lbs.	3.00 lbs.
Total Digestible Food.....	.60 lbs.	2.62 lbs.	11.72 lbs.

The digestibility of the ensilage is here assumed to be the same as green corn.

This ensilage ration was fed to all four cows during the third period of twenty days.

The dried fodder corn, as stated above, was cut and crushed in a machine which leaves it in such a condition that cows can eat it easily. After the first day or two in the first period, the dried corn ration was eaten without waste. During the second period one of the cows seemed unable to eat all of the harder pieces of ensilage; the amount wasted, however, was regarded as too small to be taken into account. *The facts therefore seem to show, that dried fodder corn when cut and crushed is eaten quite as readily and with as little waste as ensilage.*

During the entire experiment the cows were milked twice daily, at 4 A. M. and at 4 P. M. The milk of each cow was weighed separately and its weight at once recorded.

Analyses of the milk were made on five consecutive days in each period. For this purpose sample No. I. represented the total daily yield of cows I. and II., while sample No. II. represented that of cows III. and IV. Results obtained when the cows were fed ensilage are for the sake of comparison printed in heavy type.

	NUMBER OF EACH COW.			
	I.	II.	III.	IV.
Calved	Nov. 14, 1881..	Nov. 23, 1881..	Aug. 1, 1881...	Aug. 1, 1881...
Served	Jan. 27, 1882...	Jan. 7, 1882....	Sept. 18, 1881..	Oct. 1, 1881....
Yield of Milk during first period	624 lbs.	540 lbs.	339 lbs.	350 lbs.
Yield of Milk during second period	624 lbs.	526 lbs.	340 lbs.	401 lbs.
Yield of Milk during third period	579 lbs.	500 lbs.	300 lbs.	386 lbs.
Total Yield of each Cow for 60 days...	1827 lbs.	1566 lbs.	979 lbs.	1137 lbs.

In the following tables cows I. and II. from herd No. I., cows III. and IV. herd No. II. The analytical results given below are *averages*, drawn from the daily determinations of the milk of five consecutive days in each period.

	Herd No. I.					Herd No. II.				
	Specific Gravity.	Total Solids.	Butter.	Proteine.	Sugar and Ash.	Specific Gravity.	Total Solids.	Butter.	Proteine.	Sugar and Ash.
First period	10340	13.55	4.27	3.31	5.87	10340	13.87	4.27	3.43	6.17
Second period	10327	13.55	4.49	3.11	5.95	10343	14.01	4.42	3.41	6.18
Third period	10330	13.87	4.58	3.20	6.09	10346	14.51	4.53	3.59	6.39

As cows advance in their periods of lactation, the per cent. of solid matter in their milk gradually increases; while the yield of milk as is well known decreases. A second table is therefore given, in which the absolute amounts of butter, proteine, etc., yielded by each herd during each period are compared.

	Total Solids.		Butter.		Proteine.		Sugar and Ash.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
	LBS.	LBS.	LBS.	LBS.	LBS.	LBS.	LBS.	LBS.
Total Weight Yielded during 1st period..	157.7	95.5	49 7	29.4	38.5	23.6	68.3	42.5
Total Weight Yielded during 2d period...	155.8	103.8	51.6	32.7	35.8	25.2	68.4	45.8
Total Weight Yielded during 3d period...	149.6	99.5	49.4	31.0	34.2	24.6	65.7	43.8

A summary of the facts shown in the above experiment is as follows:

First.—When the green corn was dried in stacks the loss of food was less than it was when the corn was packed in a silo.

Second.—When dried corn fodder was cut and crushed it was eaten by the cows under experiment quite as readily and with as little waste as ensilage.

Third.—In three cases, the yield of milk was not increased when ensilage was substituted for dried corn, but in one case ensilage caused an increase of eighty-seven pounds of milk in forty days.

Fourth.—In the mixed milk for twenty days of herd No. I., ensilage caused no increase in the yield of total solid matter; while in the milk of herd No. II. for the same period it caused a gain of eight and one-third pounds, or seven per cent.

FEEDING EXPERIMENTS WITH SORGHUM SEED.

1. It is claimed that on land where corn does not pay expenses, sorghum yields well, its roots finding food in the subsoil.

2. The fact that it is a deep-rooting plant enables it to stand quite a severe drought without serious injury.

3. Some of the late maturing varieties, as the *Orange*, furnish abundant green fodder until killed by heavy frost.

4. The yield of amber seed and stalk is about the same as that of Indian corn; *but after the seeds are ripe and hard the stalks are still green, and apparently suitable for ensilage.* This point is especially important. Should sorghum prove suitable for this purpose the same field might be made to yield from ten to fifteen tons of green fodder per acre, with from twenty to thirty bushels of clean seed, equal in weight to shelled corn, which it approaches closely in feeding value, as will be seen below. An experiment with twenty tons of cut and crushed sorghum is now packed in a silo on the College farm.

Attention has been almost entirely directed to producing heavy crops of cane for sugar making, with little or no regard to seed development. Yields of fifty bushels are indeed on record, but such yields must be considered exceptional, from twenty to thirty bushels per acre being nearer an average.

In chemical composition, sorghum meal is almost identical with corn meal. But in the South and West it is regarded with suspicion; although in both sections men can be found who use it not only for their stock, but also for household purposes. In a recent report by Dr. Weber and Prof. Scovell, of the Illinois Industrial University, it is stated that, owing to *tannin*, which is claimed to be present, sorghum-seed meal will hardly find extensive use as stock feed. On the other hand, Dr. Collier, in the report of the U. S. Department of Agriculture for 1880, publishes his inability to detect *tannin* in the seed, of certain varieties, at least, of sorghum, and believes that the meal will

be valuable stock food. He expresses an opinion, however, that *tannin* may exist in the seed hulls. In the feeding experiment reported below these hulls were almost entirely removed from amber seed by the threshing machine.

The principal object of this experiment was to note the effect of large quantities of sorghum meal on the health of milch cows. Incidentally it was hoped to gain some idea of its digestibility compared with corn meal.

Three cows, well known as steady milkers, were fed daily a ration made up for each 1,000 pounds of live weight of

	Proteine.	Fat.	Carbhydrates.
20 lbs. of Brewers' Grains	1.05 lbs.	.26 lbs.	2.02 lbs.
9 lbs. of *Corn Meal*	.60 lbs.	.31 lbs.	6.00 lbs.
5 lbs. of Field Corn Stalks	.13 lbs.	.05 lbs.	2.56 lbs.
5 lbs. of Bran	.70 lbs.	.15 lbs.	2 32 lbs.
Total Digestible Food	2.48 lbs.	.77 lbs.	12.90 lbs.

The grains, corn meal and bran were moistened and thoroughly mixed, but it was found best to feed the cut and crushed cornstalks dry.

The milk was carefully weighed each day, and chemical analysis of it made on four consecutive days.

At the close of the first period of twenty days sorghum meal was added, little by little, to this ration, and equal weights of corn meal subtracted from it, until at the end of two weeks the ration stood

	Proteine.	Fat.	Carbhydrates.
20 lbs. of Brewers' Grains	1.05 lbs.	.26 lbs.	2.02 lbs.
9 lbs. of *Sorghum Meal*	.59 lbs.	.30 lbs.	6.00 lbs.
5 lbs. of Field Corn Stalks	.13 lbs.	.05 lbs.	2 56 lbs.
5 lbs. of Bran	.70 lbs.	.15 lbs.	2.32 lbs.
	2.47 lbs.	.76 lbs.	12.90 lbs.

During the second period of twenty days the milk was also weighed and analyzed as in the first period. The sorghum ration was eaten without waste, and no change in the health of either of the cows was noticed.

A marked decrease in the *yield* of milk occurred almost immediately when the full sorghum meal ration was fed. But as it could with reason be claimed that this decrease might have taken place had no change whatever been made in the food, it was decided at the close of this second period to put the cows on the corn meal ration again, in order to see whether this would cause an increase, compared with

the yield from the sorghum meal. An increase followed the change, and it must be admitted that pound for pound sorghum meal yields less milk than corn meal, the difference amounting to at least seven per cent.

In calculating these rations it was *assumed* that 79 per cent. of the proteine, 85 per cent. of the fat and 91 per cent. of the carbhydrates of sorghum meal could be considered digestible, these percentages representing the digestibility of corn meal. The fact that sorghum meal decreased the yield of milk seems to indicate that its digestibility is slightly lower than that of corn meal:

The conclusions reached are:

1. Sorghum meal, from amber seed, freed from hulls and fed as above stated, had no injurious effect on the health of milch cows.

2. It exerted no noticeable influence on either the taste, color or chemical composition of the milk.

3. In digestibility it probably stands slightly below corn meal, for when fed pound for pound the corn meal ration yielded seven per cent. more milk.

The figures on which these conclusions rest are given below.

CONDITION OF COWS.

	I.	II.	III.
Calved	Nov. 14, 1881.	Nov. 23, 1881.	Jan. 24, 1882.
Served	Jan. 27, 1882.	Jan. 7, 1882.	March 13, 1882.
Weight, Feb. 3, 1882	930 lbs.	885 lbs.	835 lbs.
Weight, May 5, 1882	955 lbs.	975 lbs.	925 lbs.

AVERAGE DAILY YIELD OF MILK.

	I.	II.	III.
Corn Meal Ration, Feb. 22—March 13	28.6 lbs.	24 9 lbs.	30.9 lbs.
Sorghum Meal Ration, March 27—April 16	24 2 lbs.	22 3 lbs.	28 6 lbs.
Corn Meal Ration, April 21—30	25.8 lbs.	23.9 lbs.	31.4 lbs.

CHEMICAL COMPOSITION OF THE MILK.

	AVERAGE OF FOUR DETERMINATIONS.				
	Specific Gravity.	Total Solid Matter.	Butter.	Proteine	Sugar and Ash.
From Corn Meal Ration	1.0344	13.88	4.16	3 65	6.08
From Sorghum Meal Ration	1.0348	14.12	4.29	3.66	6.18

DONATIONS.

Messrs. Lister Brothers, of Newark, have given one ton of their ammoniated superphosphate of lime for trial on the College farm. It was used on the present growing wheat, which is very promising.

Messrs. Hauck & Comstock, of Mechanicsburg, Penn., have presented to the farm a No. 1 Lion Cutter and Crusher, with carrier attached. The machine has been tried and it fully sustains the promises of its manufacturers. It is easily driven by a tread-power and good pair of mules. With the cutter only, three or four tons of green, but full-grown, corn-stalks were cut in an hour, and with the crusher on, one ton of ripe, but juicy, sorghum canes was cut and crushed for ensilage in an hour.

3 0112 105948761